University of Alberta

Petrology Of The Meliadine Kimberlite Dykes, District Of Keewatin, Northwest Territories, Canada

by

Michael H. Seller ©

A thesis submitted to the Faculty of Graduate Studies and Research in partial fulfillment of the
requirements for the degree of Master of Science

Department of Earth and Atmospheric Sciences

Edmonton, Alberta

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Faculty of Graduate Studies and Research

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Dr. Robert W. Luth (supervisor)

Dr. Robert A. Creaser (committee chair)

Dr. Doug R. Schmitt (committee member)

Date Nov 5 /98

Dedication

To my parents.

Abstract

Barren kimberlite dykes were discovered in three separate diamond drill holes during 1996 on the Meliadine gold property, District of Keewatin, Northwest Territories, Canada. These dykes are situated within the supracrustal rocks of the ca. 2.66 Ga Rankin Inlet Group Churchill Province. The dykes are best classified as kimberlite based on mineralogy, mineral chemistry, major and trace element whole-rock geochemistry, and Sr-Nd isotopic compositions. All dykes display characteristics of evolved carbonate-rich kimberlites, as they are characterized by high amounts of carbonate, scarcity of mantle-derived megacrysts, general lack of Cr-bearing spinels, and abundance of Ti-rich spinels.

U-Pb geochronology on two perovskite fractions from selected dykes yielded an Early Jurassic $^{206}Pb/^{238}U$ isochron age of 192 ± 13 Ma. The age is of uncertain reliability, but represents a best estimate for the age of emplacement. The Meliadine kimberlites therefore represent the first dated and recognized kimberlite magmatic event within the Archean Churchill Province.

Aknowledgements

I am greatful to Comaplex Minerals Corp., for allowing me to do work on the Meliadine kimberlites and for employment during the 1996 field season; thanks to Mark Balog, Phillip Mudry, and everyone else who was there for the summer. I'd especially like to thank Allan Armitage of CMC for always opening his home to me, and just being a friend, thanks Al! I would also like to thank Cumberland Resources Ltd., for also allowing me to do work on the Meliadine kimberlites.

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CHAPTER 1

INTRODUCTION

Comaplex Minerals Corp. discovered seven kimberlite dykes in diamond drill core in 1996 on the Meliadine gold property. The property is situated within the 2.66 Ga Archean supracrustal rocks of the Rankin Inlet Group, Churchill Province, Northwest Territories, Canada. Kimberlites were intersected in the following diamond drill holes: (1) ML96-121 intersected Peter I and Peter II dykes; (2) ML96-136 cut K-L 2A, 2B, 2C, and 2D dykes; and (3) ML96-153 intersected the October dyke (Table 1.1). The kimberlites occur as subvertical, steeply dipping, tabular bodies 0.20-2.00 m in apparent width. Emplacement is controlled by the preexisting regional fracture patterns of the region (east-southeast and northwest). The dykes appear to anastamose and they are heterogeneous in appearance as a result of flow differentiation. Contact metamorphic effects in country rocks and incorporated country rock xenoliths are minimal. All of these features are consistent with hypabyssal facies kimberlite dykes (Mitchell, 1986). Also encountered was a single ultrapotassic dyke (Aya) in ML96-136, which may be correlated with the extensive ultrapotassic volcanisim of the ca. 1.84 Ga Christopher Island Formation of the Keewatin hinterland.

Table 1.1. Diamond drill hole and kimberlite dyke intersection depths with apparent intersection widths in brackets.

DIAMOND DRILL HOLE	DEPTH (m)
ML96-121	
Peter I	18.70-19.07 (0.37m)
Peter II	25.67-26.40 (0.73m)
ML96-136	
K-L 2A	43.72-45.63 (1.91m)
K-L 2B	53.20-54.24 (1.04m)
K-L 2C	69.00-69.56 (0.56m)
K-L 2D	95.16-95.66 (0.50m)
Aya	102.54-103.75 (1.21m)
ML96-153	
October	121.25-121.45 (0.20m)

Kimberlites are found at fourteen locations within Canada (Figure 1.1), with economic occurrences only found to date in the Archean Slave Province. The diamond potential of the Churchill Province is exemplified by the Akluilâk dyke, a 1832 ± 28 Ma diamondiferous lamprophyre dyke, that lies approximately 120 km northwest of Rankin Inlet, in the Gibson Lake area, Northwest Territories, Canada (MacRae et al., 1996, 1995). This dyke is unique in its high concentration of microdiamonds. To date, three bulk samples have been processed from the dyke (MacRae et al., 1996, 1995): (1) a 22 kg sample returned 1765 microdiamonds, and two macrodiamonds (> 500 μm); (2) a 32.8 kg sample yielded 1157 microdiamonds and 6 macrodiamonds; and (3) a 7.8 kg sample returned 6677 microdiamonds and 3 macrodiamonds. The Akluilâk dyke is not economic, but its presence indicates the preservation of diamonds beneath the Churchill Province.

Diamonds may be stable at depths of 150-200 km (~ 50-65 kbar) within the thick cool lithospheric roots beneath stable Archean cratons, with a temperature range of 900-1200 °C (Boyd and Gurney, 1986; Boyd et al., 1985). Mantle roots underlying tectonically stable old cratons (i.e., Churchill Province) can be located and defined by shear velocities obtained from high-resolution seismic tomography (Grand, 1987; Anderson et al., 1992; Polet and Anderson, 1995). Cool lithospheric roots appear as high velocity anomalies (HVA), whereas hot regions such as midocean ridges, tectonically active(unstable) areas, or volcanic regions appear as low velocity anomalies (LVA). The surface manifestation of HVAs beneath stable cratons are low surface heat flows within the interiors of Archean cratonic nuclei, typically 40 mW m^{-2}, compared to considerably higher values of 60 mW m^{-2} in the surrounding younger orogenic belts (LVAs) [Ballard and Pollack, 1987]. Figure 1.2 is a simplified model of a cross section through a diamondiferous cratonic root that diagrammatically combines the diamond stability field with the aforementioned high-resolution seismic tomographic data.

High-resolution tomographic data indicate the presence of a cool, thick (~ 250 km) lithospheric root beneath the Archean Churchill Province (Polet and Anderson, 1995). This region is compatible with the P-T characteristics essential for diamond stability, and therefore kimberlites traversing through this root may incorporate potentially diamondiferous peridotite and eclogite. The Churchill Province however has experienced extensive reactivation and reworking during 1.9-1.8 Ga compared to the adjacent Superior and Slave cratons (Hoffman, 1990); such reworking could have diminished the cratonic root of the Churchill. The effect this reworking has had on the diamond potential of the root is unknown and will remain so until data from deep-seated xenoliths (ideally from kimberlites) are recovered from beneath the Churchill. Overall, the Churchill Province is an attractive diamond prospective region, similar to that of the diamond-producing Slave and Kaapvaal cratons, and the Siberian platform.

The purpose of this study is to define the character (kimberlite, orangeite, lamproite, or lamprophyre) of the Meliadine dykes by using petrography and mineral chemistry, major and trace element geochemistry, strontium-neodymium isotopic systematics, and U-Pb geochronology. Samples were selected based on the varying appearance of the dykes, macroscopic differences in mineralogy, competency of the core, and absence of country-rock xenoliths. Using these criteria, the most representative suite of samples possible were selected that encompassed the range of textures and lithologies observed in the dykes. All samples were derived from Peter I and II, and the K-L 2A and 2B intersections.

Petrography in conjunction with mineral chemistry is perhaps the most useful method in accurately classifying kimberlites because superficially similar rocks do exist, such as ultramafic lamprophyres, olivine lamproites, and orangeites. Determination of the compositional trends of minerals such as phlogopite and spinel are crucial. Phlogopite and spinel compositional trends from kimberlites are distinct, and reflect the geochemical characteristics of the parental magma, such that compositional variation of these phases may be used to discriminate between superficially similar rocks (Mitchell, 1995a). In addition, the absence of minerals such as feldspars and feldspathoids, the absence of which are characteristic of kimberlites, is distinctive because these are common phases in lamprophyres and lamproites. Although geochemistry is used in this study, by itself it is not a very suitable method for classification because of the hybrid nature of kimberlites, and the possible contamination of the sample resulting from incorporation of crustal material and(or) interaction with groundwater. Geochemistry does however provide a basis for comparison with other kimberlites of similar character (e.g., hypabyssal kimberlites).

The diamond potential of the dykes is addressed by analysis of minerals obtained from heavy mineral concentrates. The abundance and major element compositions of traditionally used diamond indicator minerals, ilmenite, chromite, and garnet, is used to assess the diamond potential of the dykes and that of the source region.

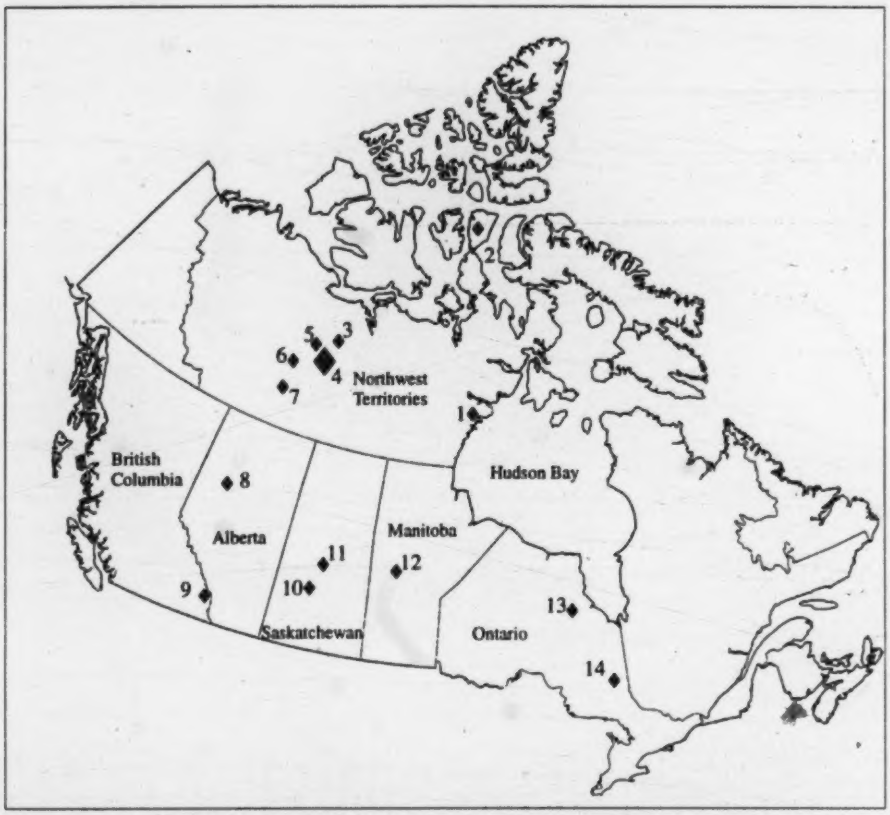

Northwest Territories
Hudson Bay
British Columbia
Alberta
Saskatchewan
Manitoba
Ontario
1
2
3
4
5
6
7
8
9
10
11
12
13
14

Figure. 1.1. Location map of kimberlites in Canada: (1) Meliadine dykes; (2) Somerset Island field; (3) Jericho; (4) Lac de Gras field (e.g., Ekati Diamond Mine, Diavik, Yamba Lake); (5) Ranch Lake; (6) Cross Lake; (7) Dry Bones Bay; (8) Buffalo Hills field; (9) Crossing Creek; (10) Fort a la Corne field; (11) Candle Lake field; (12) Snow Lake-Wekusko; (13) Attawapiskat field ; and (14) Kirkland Lake and Lake Timiskiming fields (modified from Kjarsgaard, 1996a).

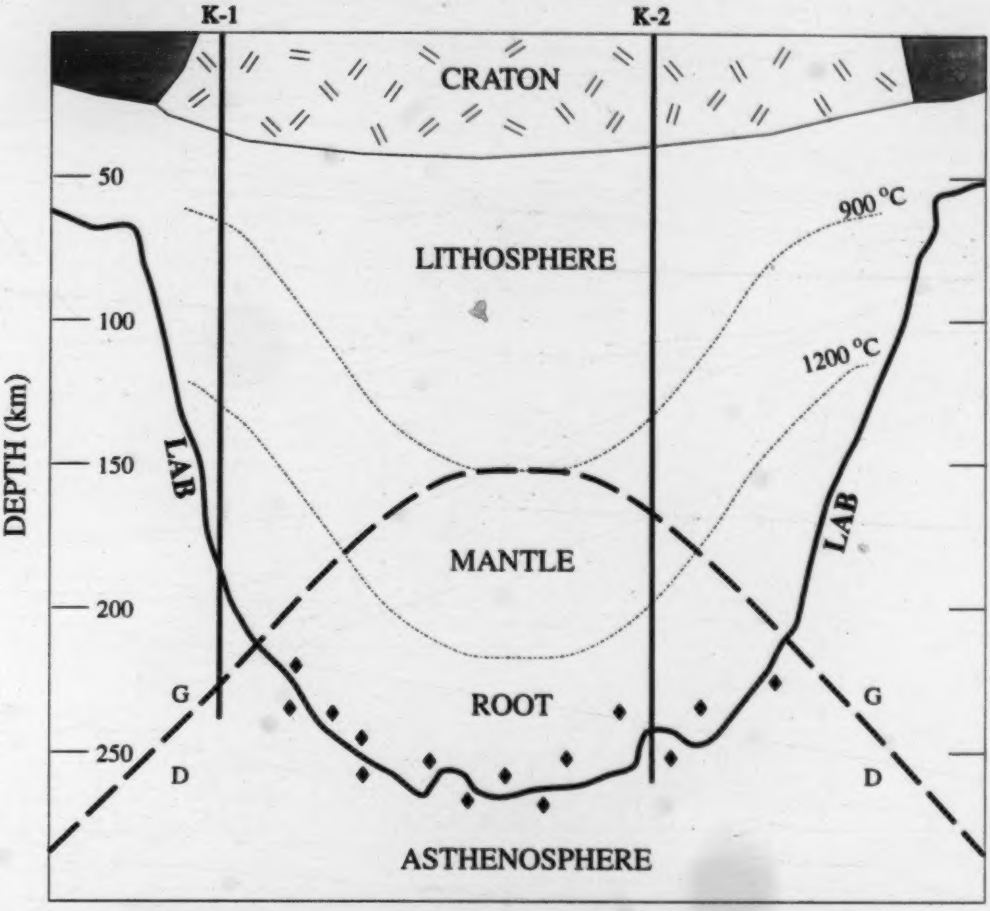

K-1
K-2
CRATON
LITHOSPHERE
900 °C
1200 °C
DEPTH (km)
50
100
150
200
250
LAB
LAB
MANTLE
ROOT
G
D
G
D
ASTHENOSPHERE

Figure 1.2. A simplified cross section of a diamondiferous lithospheric mantle root (not to scale) beneath a stable Archean craton (modified from Haggerty, 1986). Displayed are: concave isotherms for 900 °C and 1200 °C in the lithosphere; a convex diamond stability field (D = diamond, G = graphite) displaying a diamondiferous mantle root (black diamonds); LAB= lithosphere/asthenosphere boundary. High velocity anomalies (HVA) are represented by the thick cool lithospheric root, and low velocity anomalies (LVA) are represented by the thinner and younger mobile belts (shaded regions). Intrusion of a kimberlite magma could be expected to be diamondiferous (K-2), and barren (K-1).

CHAPTER 2

GEOLOGICAL SETTING

The Meliadine kimberlites are located within the Churchill Province, an Archean craton similar in nature to other Archean cratons, in that it is composed of high grade gneiss terranes, granite-greenstone belts, intracratonic basins, and intrusive complexes. The following summary of the development, nature, and history of the Churchill Province is based on Hoffman (1990, 1988). The Churchill Province is surrounded by Early Proterozoic collisional zones (Fig. 2.1), and as a consequence the Churchill has seen reworking during these Proterozoic events. To the west of the Churchill lies the 2.02 to 1.91 Ga Thelon Orogen where a dextral-oblique collision with the Slave occurred with an east dipping subduction polarity. To the east is the 1.91 to 1.81 Ga Trans-Hudson Orogen where the northwest margin of the Superior collided with the Churchill with northwest dipping subduction. The collision between the Superior and the Churchill was a Himalayan-type event in which the hinterland (Churchill Province) experienced reworking in a Tibetan-type plateau environment as a result of the collision (Dewey and Burke, 1973).

The Churchill has been subdivided into the Archean Rae and Hearne Provinces, each consisting of Archean basement comprising granite-greenstone terranes or their high grade equivalents, overlain by erosional remnants of Early Proterozoic sedimentary cover (Fig. 2.2). The supracrustal rocks of the Rae and Hearne Province range in age from 2.7 to 1.7 Ga and are separated from one another by the Snowbird Tectonic Zone (STZ), which is an anastomosing network of granulite grade mylonites and bodies of anorthosite-gabbro-pyroxenite. The exact nature and meaning of the STZ is controversial, but may represent a suture based on gravity anomalies (Hoffman 1990 and 1988, and references therein).

GEOLOGY OF THE RANKIN INLET GROUP

The supracrustal rocks of the Rankin Inlet Group (Fig. 2.3) were originally defined by Bannatyne (1958) to represent a sequence of metamorphosed and polydeformed Archean supracrustal rocks composed of felsic and mafic volcanics and related pyroclastics, banded oxide iron-formation, greywacke-argillite sediments, and ultramafic intrusions that outcrop in the Rankin Inlet area. Later regional mapping (Tella et al., 1986) and age dating of the Rankin Inlet Group (Tella, 1994) found that the Group is a 2.66 Ga greenstone belt consisting of at least two major cycles of mafic volcanism that are separated by an intervening cycle of greywacketurbidite deposits that contain banded oxide iron-formations. Following deposition, the Rankin Inlet supracrustal rocks were polydeformed and metamorphosed regionally to greenschist to amphibolite facies (Tella et al., 1986, 1992, 1993).

The current interpretation of deformation within the Group invokes at least two Archean events and one Proterozoic event (Tella et al., 1986; Tella, 1995). Archean deformation led to the development of an F_1 homocline dipping to the ESE, that was subsequently refolded to give an F_2 syncline plunging shallowly to the SE (Tella et al., 1986; Tella, 1995). The Proterozoic deformational event resulted in the tectonic interleaving of Archean metavolcanic rocks with Proterozoic Hurwitz orthoquartzite. The Hurwitz orthoquartzite occurs as scattered narrow linear outcrops within regions of the Rankin Inlet Group (Tella et al., 1986). During the late Archean to the Early Proterozoic, gabbro and diabase intruded the Group. This sequence of events was then later followed by post tectonic granitoid intrusions, phlogopite lamprophyres, and lastly, northwest trending Proterozoic Mackenzie dykes.

GEOLOGY OF THE MELIADINE PROPERTY

The Meliadine kimberlite dykes are located within the Meliadine Property (Fig. 2.4), approximately 20 kilometres north of the hamlet of Rankin Inlet, Keewatin District, Northwest Territories (NTS map sheets 55J/13 and 55J/14). The property extends inland from the coast a distance of 70 kilometres. On the property, two semi-continuous, geophysically distinct, northwest-trending, linear aeromagnetic features form the Meliadine Trend in the supracrustal rocks of the 2.66 Ga Rankin Inlet Group. These aeromagnetic linears correspond to quartz + carbonate veined iron-formations spatially associated with a 1-2 km wide fault zone. This zone shows evidence for ductile to brittle strain with apparent dextral displacement (Lewis et al., 1996; Miller et al., 1995). The zone, a major structural feature that strongly influences the geology of the Meliadine trend, is informally termed the Pyke Break and shows no distinct geophysical signature itself (Lewis et al., 1996). The Pyke Break was interpreted by Balog (1993) and Tella (1994) to be an Archean thrust that underwent reactivation during the late Archean to Proterozoic.

Lithologies represented within the Meliadine trend include greywacke-argillite sediments, mafic volcanics, flows, and tuffs, iron-formation, porphyritic gabbro dykes, lamprophyre dykes, and kimberlite dykes. The exact nature of the geology in the Meliadine Trend has not been precisely determined because of the severe lack of outcrop in the region resulting from extensive overburden. Interpretation of geological and structural data have all been deduced from limited geological mapping, detailed airborne and ground geophysical surveys, and diamond drill hole data. Based on these data, Miller et al. (1995) interpreted that a facies change occurs along the north side of the Meliadine Trend on a regional scale. The region to the east of the Discovery area is dominated by sediments, whereas volcanic rocks dominate in the western part of the area.

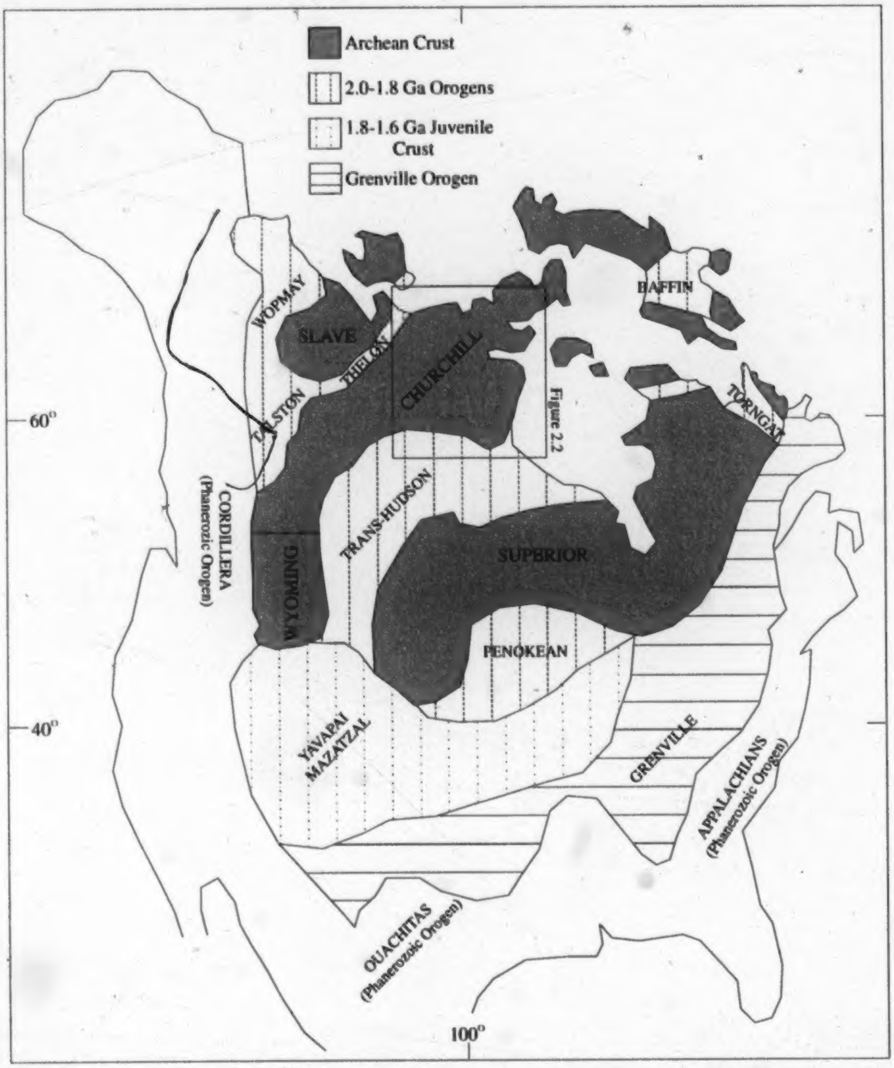
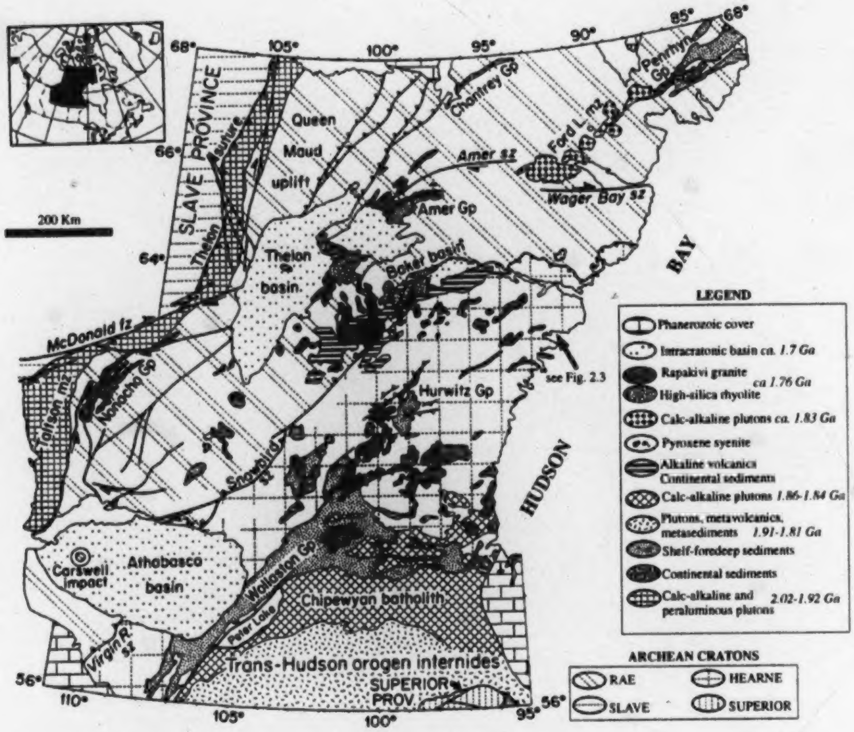

Archean Crust
2.0-1.8 Ga Orogens
1.8-1.6 Ga Juvenile Crust
Grenville Orogen
WOPMAY
SLAVE
THELON
TALSTON
CHURCHILL
Figure 2.2
BAFFIN
TORNGAT
TRANS-HUDSON
SUPERIOR
WYOMING
CORDILLERA (Phanerozoic Orogen)
PENOKEAN
YAVAPAI MAZATZAL
GRENVILLE
APPALACHIANS (Phanerozoic Orogen)
OUACHITAS (Phanerozoic Orogen)
60°
40°
100°

Figure 2.1. Precambrian tectonic elements of North America (modified from Hoffman, 1988).



200 Km
68°
105°
100°
95°
90°
85°
68°
66°
64°
56°
110°
105°
100°
95°
56°
SLAVE PROVINCE
Thelon suture
Queen Maud uplift
Chantrey Gp
Penrhyn Gp
Ford L. mz
Amer sz
Wager Bay sz
Amer Gp
Thelon
Thelon basin
Baker basin
BAY
McDonald fz
Nonacho Gp
Taltson mz
Snowbird
Hurwitz Gp
see Fig. 2.3
HUDSON
Carswell impact
Athabasca basin
Wollaston Gp
Chipewyan batholith
Peter Lake
Virgin R. sz
Trans-Hudson orogen internides
SUPERIOR PROV.
LEGEND
Phanerozoic cover
Intracratonic basin ca. 1.7 Ga
Rapakivi granite
High-silica rhyolite
ca 1.76 Ga
Calc-alkaline plutons ca. 1.83 Ga
Pyroxene syenite
Alkaline volcanics
Continental sediments
Calc-alkaline plutons 1.86-1.84 Ga
Plutons, metavolcanics, metasediments 1.91-1.81 Ga
Shelf-foredeep sediments
Continental sediments
Calc-alkaline and peraluminous plutons 2.02-1.92 Ga
ARCHEAN CRATONS
RAE
HEARNE
SLAVE
SUPERIOR

Figure 2.2. Map of the Archean Churchill Province showing the Rae and Hearne subdivisions (modified from Hoffman, 1988).

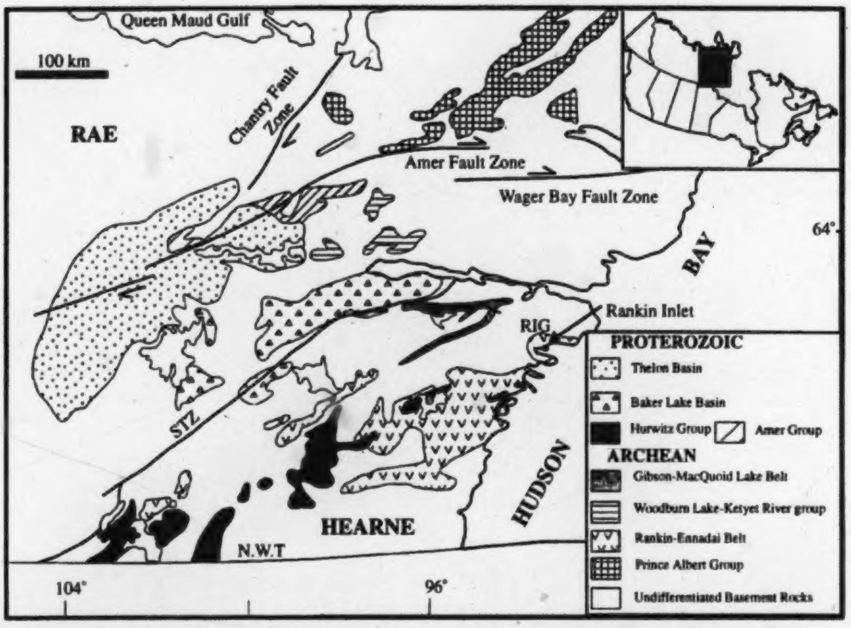

Queen Maud Gulf
100 km
RAE
Chantry Fault Zone
Amer Fault Zone
Wager Bay Fault Zone
64°
BAY
Rankin Inlet
RIG
STZ
HEARNE
HUDSON
N.W.T
104°
96°
PROTEROZOIC
Thelon Basin
Baker Lake Basin
Hurwitz Group
Amer Group
ARCHEAN
Gibson-MacQuoid Lake Belt
Woodburn Lake-Ketyet River group
Rankin-Ennadai Belt
Prince Albert Group
Undifferentiated Basement Rocks

Figure 2.3. Simplified regional geological map of the central Churchill Province (Rae and Hearne) displaying the location of the 2.66 Ga Rankin Inlet Group (RIG), and the Snowbird Tectonic Zone (STZ) [modified from MacRae et al., 1995].

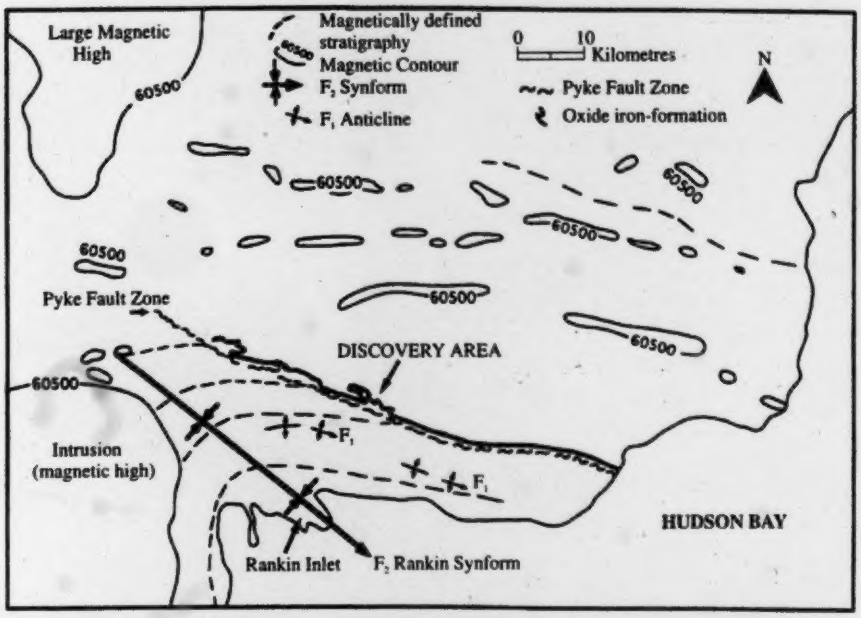

Large Magnetic High
60500
Magnetically defined stratigraphy
Magnetic Contour
F_2 Synform
F_1 Anticline
0 10 Kilometres
Pyke Fault Zone
Oxide iron-formation
N
Pyke Fault Zone
DISCOVERY AREA
Intrusion (magnetic high)
F_1
HUDSON BAY
Rankin Inlet
F_2 Rankin Synform

Figure 2.4. Aeromagnetic map of the Meliadine Property showing the distribution of iron-formation and the Pyke Fault Zone. Note that the Meliadine Trend is defined by the oxide iron-formation (modified from Miller et al., 1995).

CHAPTER 3

DEFINITIONS OF KIMBERLITE PHASES: PRIMARY AND CRYPTOGENIC

Kimberlites in general exhibit a distinctive inequigranular texture resulting from large rounded-to-anhedral crystals set in a finer-grained matrix (Mitchell 1986, 1995b). The possible origin of these phases as cognate or xenocrystic led Clement et al. (1984) and Mitchell (1986) to propose that these cryptogenic phenocrystal phases be referred to as megacrysts or macrocrysts, to avoid any genetic connotations. In this study these terms are used in the following way (after Mitchell 1995b):

Megacrysts are rounded-to-anhedral crystals > 10 mm in their maximum dimension. Megacrystal kimberlites are defined as having > 5 vol. % of such crystals.

Macrocrysts are rounded-to-anhedral crystals 0.5-10 mm in their maximum dimension. Many macrocrysts are fragmented megacrysts. Macrocrystal kimberlites are defined as containing > 5 vol. % of such crystals.

Macrocrystal clasts or **microcrysts** are small crystals (< 0.5 mm to commonly 1-500 μm), compositionally similar to megacrysts and macrocrysts, that are scattered throughout the groundmass. These grains are interpreted as fragmented megacrysts and macrocrysts.

Phenocrysts and **microphenocrysts** (> 0.5 mm and 0.1-0.5 mm respectively) are of subhedral-to-euhedral habit and are considered to be early forming, primary magmatic phases.

Groundmass phases are primary phases typically < 0.1 mm and of euhedral-to-anhedral habit that constitute the bulk of the fine grained groundmass. Groundmass phases may be set in a primary matrix or mesostasis that is very fine grained to optically unresolvable. The groundmass phases typically cease crystallizing before the formation of the mesostasis.

Mineralogy of Primary and Cryptogenic Phases, Mitchell (1995b)

Crystals within kimberlites are derived from three distinct sources: (1) mantle-derived xenoliths; (2) the Cr-poor megacryst/macrocryst suite (discrete nodule suite); and (3) primary phases crystallizing from the kimberlite magma itself. The contribution from each of these sources is highly variable, and as a result kimberlites are mineralogically complex rocks.

Mantle-derived xenoliths consist of garnet lherzolite (the source for chrome diopside and Cr-pyrope), spinel lherzolite, garnet harzburgite (the source for subcalcic knorringitic garnets) and chromite harzburgite, websterite, eclogite, and grosspydite (the source for xenocrysts of jadeitic pyroxenes, kyanite, and grossular-rich garnets), the MARID (mica-amphibole-rutile-ilemenite-diopside) suite of rocks, and metasomatized peridotites containing potassic richterite, phlogopite, and the titanates. Incorporation and disaggregation of these xenocrysts into the kimberlite contributes a wide variety of xenocrysts to the kimberlite magma. The origin(s) of these xenocrysts can be determined based on their compositions relative to minerals in the parental xenoliths. Some xenocrysts, however, are compositionally more akin to primary phases crystallizing out of the magma (such as olivine and phlogopite). Because there is no satisfactory means to distinguish between the two modes of origin, they are commonly included in the macrocryst suite.

The Cr-poor megacryst/macrocryst suite consists predominantly of individual crystals of magnesian ilmenite, Cr-poor titanian pyrope, Cr-poor subcalcic diopside, enstatite, phlogopite, and zircon. Based on textural characteristics and chemical variations, these megacrysts are interpreted to represent a series of minerals precipitating from a magma. The relationship of this magma to the kimberlite has not been resolved satisfactorily to date (cf. p.6 Mitchell, 1995b and references therein).

ARCHETYPAL KIMBERLITE DEFINED, MITCHELL (1995b)

"Kimberlites are a group of volatile-rich (dominantly CO_2) potassic rocks commonly exhibiting a distinctive inequigranular texture resulting from the presence of macrocrysts (and in some instances megacrysts), set in a fine grained matrix. The mega/macrocrysts assemblage consists of anhedral crystals of olivine, magnesisn ilmenite, Cr-poor titanian pyrope, diopside (commonly subcalcic), phlogopite, enstatite, and Ti-poor chromite. Olivine macrocrysts are a characteristic constituent in all but fractionated kimberlites. The matrix consists of a second generation of primary euhedral-to-subhedral olivine which occurs together with one or more of the following primary minerals: monticellite, phlogopite, perovskite, spinel (magnesian ulvöspinel-Mg-chromite-ulvöspinel-magnetite solid solutions), apatite, and serpentine. Many kimberlites contain late-stage poikilitic micas belonging to the barian phlogopite-kinoshitalite series. Nickeliferous sulphides and rutile are common accessory minerals. The replacement of earlier formed olivine, phlogopite, monticellite, and apatite by deuteric serpentine and calcite is common. Evolved members of the group may be poor in, or devoid of, macrocrysts and/or composed essentially of second-generation olivine, calcite, serpentine, and magnetite, together with minor phlogopite, apatite, and perovskite."

TEXTURAL-GENETIC AND MINERALOGICAL CLASSIFICATION OF MELIADINE KIMBERLITES

Figure 3.1 illustrates an idealized model for a kimberlite magmatic system (after Mitchell, 1986), illustrating that kimberlites commonly occur as carrot-shaped pipes, or as dykes, and more rarely as sills. Currently, three textural genetic groups differentiate kimberlite lithologies (after Mitchell, 1986): (i) crater facies, (ii) diatreme facies, and (iii) hypabyssal facies. Because of the dyke morphology of the Meliadine kimberlites, I will focus on (iii).

Hypabyssal facies kimberlites occur in the root zones of diatremes, and as dykes and sills. This facies of kimberlite is formed by the crystallization of a volatile-rich magma, and may display typical igneous textures and the effects of magmatic differentiation. Root zones are transitional from diatreme to hypabyssal facies kimberlite. These zones are recognized by an abrupt change in morphology from the carrot-shaped form of the diatreme to the highly irregular form of the root zone. Sills are a relatively rare occurrence, with their formation controlled by the local structural patterns. Dykes generally occur as 1-3 m wide tabular, vertically dipping bodies that can be traced for several kilometres along strike, or as isolated bodies. Bifurcation or splitting of the dykes into anastomosing stringers is a common feature. Dykes are commonly single intrusions with emplacement being controlled by the regional fracture pattern. Many dykes exhibit a heterogeneous appearance resulting from flow differentiation, with minimal contact metamorphic effects. Classification of dykes is based on the amount of incorporated xenolithic material (kimberlite to kimberlite breccias), with subdivisions based on abundances of macrocrysts present (aphanitic to macrocrystic kimberlite), and the amount of late crystallizing components which have crystallized into segregations (segregationary kimberlite; cf. Clement and Skinner, 1985; Skinner and Clement, 1979).

PETROGRAPHY AND MINERAL CHEMISTRY OF THE MELIADINE KIMBERLITES

In hand specimen, the core samples of the Meliadine dykes contain altered olivine macrocrysts and microphenocrysts set in a fine grained pale yellow-white to grey-green groundmass with scattered opaques visible in the groundmass. The principal variations in the appearance of the sample results from differences in the amount and colour of groundmass material. A lesser influence in appearance is from the amount of incorporated country-rock xenoliths, which rarely exceed 5 modal %. One distinctive mineralogical difference between the dykes is that only Peter I and Peter II contain microphenocrystal and groundmass phlogopite.

In thin section, K-L 2A and K-L 2B contain 30-50 modal % altered olivine, 4-10 % spinel, and < 1 % apatite, with the remainder consisting of groundmass carbonate (Fig. 3.2 and 3.3). These modes are approximate because of considerable variation observed between all thin sections. In thin section, Peter I and Peter II contain 35-40 modal % altered olivine, 1-4 % phlogopite, and 2-10 % spinel, with the groundmass consisting of carbonate ± Fe-rich serpentine accounting for the remainder (Fig. 3.3B, C). Trace rounded-to-anhedral quartz and plagioclase grains, presumably derived from crustal xenoliths, are present in the groundmass. The mineralogy and mineral chemistry for each dyke are detailed separately below.

The Peter and K-L kimberlite dykes were classified using the textural-genetic method of Clement and Skinner (1985) and Skinner and Clement's (1979) mineralogical classification. Based on these schemes, all dykes are hypabyssal macrocrystal carbonate kimberlites, with carbonate defined as dolomite + calcite. Although Skinner and Clement's (1979) classification is adequate and widely used, it does not differentiate the subtle differences in mineralogy between the Peter and K-L dykes. Skinner and Clement (1979) felt that accessory phases that exceed two thirds the volumetric abundance of the dominant mineral phase may be included in the name. Neither Peter nor K-L contain an accessory phase in these required abundances, but the presence of phlogopite in Peter and its absence in K-L is a significant feature. Therefore, Peter dykes will be classified as hypabyssal macrocrystal phlogopite-carbonate kimberlites.

Mineralogy and Mineral Chemistry of Peter I and Peter II

Mineral analyses were obtained with a JXA 8900 electron microprobe at the University of Alberta. Operating conditions were 15.0 kV acceleration voltage, 1-2 µm beam diametre, 15 nA probe current, and 20 sec counting time per element, with the raw data corrected using the ZAF correction scheme (see Appendix I for probe standards and mineral data).

Olivine

Olivine grains from Peter I and Peter II are completely pseudomorphed by a yellow alteration product, which is an intimate mixture of Fe-rich serpentine ± carbonate (dolomite and calcite) and sepiolite (a Palygorskite group clay mineral). Grain sizes range from 0.15 mm to 3.3 mm, averaging 0.5 mm. The original habit of the grains is difficult to determine because of the extensive alteration, however, many of the larger grains are likely macrocrysts based on their rounded-to-anhedral habit. The majority of the remaining olivines are possibly phenocrysts/microphenocrysts with subhedral-to-euhedral habits, although again this is difficult to determine in many instances because of the degree of alteration. A flow alignment of these phenocrysts/microphenocrysts grains is also observed. Texturally, larger olivine grains (> 1.0 mm) are sometimes mantled by phlogopite (Fig. 3.3C). Spinel also mantles some olivines as discrete grains along margins or as a necklace of spinel around the grain margin. Spinels also occur as inclusions within olivine.

Phlogopite

Mica from both dykes consist of lath-shaped (average size of 0.03 x 0.3 mm) microphenocryst and groundmass mica that may show a weak flow alignment in the groundmass. All grains display normal pleochroism, and the majority are also zoned, with pale yellow-brown cores to colourless-to-pale yellow rims (Fig. 3.3B). The rims of zoned grains are not in optical continuity with the cores, consistent with them representing later overgrowths. Microphenocrysts that lack any zonation, and groundmass micas, are a colourless-to-pale yellow similar to the rims of optically zoned grains. A single large (1.3 mm) optically zoned, rounded and broken mica grain was present in the Peter I dyke (macrocryst/phenocryst). Rare, strongly zoned microphenocrystal mica with dark brown cores and colourless-to-pale yellow rims occur only in Peter I. Fine grained inclusions of opaques typically occur in microphenocrysts, whereas groundmass micas are generally devoid of inclusions. Texturally, mica may mantle altered olivine grains as mentioned above, with the margins of these micas typically showing green chlorite alteration. Alteration of other mica phases is a common feature within the dykes. Rare glomeroporphyritic amalgamations of mica also occur.

Peter I Microphenocryst Micas

The major element chemistry of micas can be used to discriminate between kimberlites, orangeites, lamproites, minettes, and ultramafic lamprophyres (Fig. 3.4). In this study, individual point analyses for phlogopites typically consist of three analyses per rim and core, with averaged grain compositions consisting of all point analyses taken on rim and cores respectively.

Two distinct mica populations may be distinguished in Peter I microphenocryst cores and rims based on Al, Fe, and Ti contents (Fig. 3.5, Table 3.1). Population I [mg=100Mg/(Mg+Fe) of 81.34-86.02], which are dominantly core analyses, contain 13.90-14.95 wt. % Al_2O_3, 6.34-7.22 wt. % FeO_T, 2.94-3.28 wt. % TiO_2, and 0.12-1.39 wt. % BaO. Population II (mg= 86.25-88.66) micas, the majority of the analyses are comprised of cores and rims that are Al and Ba-rich (15.86-17.28 and 0.99-1.96 wt. %, respectively), and Fe and Ti-poor (5.12-6.12 and 1.82-2.31 wt. %, respectively) relative to Population I micas (PI). Considerable intra-grain compositional variation is evident, in which a single core or rim may exhibit geochemical characteristics of both

PI and PII micas, although, one population will always dominate over the other (Table 3.1 anal. 5R). Averaged compositions for individual grains show cores are transitional in composition from PI to PII, and rims are PII micas (Fig. 3.6). An overall compositional trend of increasing Al coupled with decreasing Fe and Ti-contents from core to rim is observed. This Ti-depletion and Al-enrichment is characteristic of kimberlite micas (Mitchell, 1986, 1995b; cf. Fig. 3.4).

Not plotted on Figures 3.5-3.6 are six individual point analyses of cores (2) and rims (4) from three separate grains that all display high FeO_T (11.46-19.81 wt. %), lower mg (49.83-72.81), and higher NiO (0.03-0.13 wt. %) and Na_2O contents (0.24-0.54 wt. %) than PI and PII micas (Table 3.1 anal. [Fe]). Smith et al. (1978) proposed that inter-grain geochemical differences observed in kimberlite micas likely reflect mm scale changes in the bulk composition of the kimberlite magma. These rare isolated high Fe-anomalies observed in Peter micas could reflect this effect, or they could be differentiated micas, or xenocrysts.

Peter II Microphenocryst Mica

Representative mica microphenocryst core and rim compositions for Peter II micas are given in Table 3.2, with individual point analyses and averaged compositions plotted in Figures 3.7 and 3.8, respectively. Both cores and rims (mg= 86.19-88.61) contain high Al_2O_3 (15.46-17.30 wt. %), low FeO_T (4.96-6.23 wt. %), low TiO_2 (1.15-2.29 wt. %), and high BaO (0.98-2.10 wt. %), comparable to PII micas in Peter I. Intra-grain variations in major elements is limited, and compositionally there is a decrease in Al and Ti from core to rim, with a slight decrease or increase in Fe-content; a trend more typical of orangeite mica (Fig. 3.4).

Not plotted on Figures 3.7-3.8 are two point analysis from a single core with extremely high Fe-contents compared to average Peter II micas (FeO_T of 21.19 and 21.74 wt. %). As with the Peter I high Fe-bearing micas, mg is considerably lower than normal (44.60-45.42), NiO is higher (0.11 wt. %) as are Na_2O contents (0.36-0.37 wt. %). The rim mantling the Fe-rich core is similar to other micas from Peter II. These variations may be a result of small scale variations in magma composition (see Peter I), or the core represents a xenolith incorporated into the magma that was subsequently mantled by primary kimberlite mica.

Peter I and II Groundmass Mica

Groundmass micas from Peter I (Table 3.3, Fig. 3.9) have mg= 77.91-88.90, and in general contain 14.14-17.00 wt. % Al_2O_3, 5.24-10.50 wt. % FeO_T, 1.50-2.05 wt. % TiO_2, and 0.86-1.68 wt. % BaO. These micas are similar to PII micas except for FeO_T, which may be significantly higher. Peter II groundmass micas (Table 3.3, Fig.3.9) have mg= 84.15-88.05 and contain Al_2O_3= 15.46-17.44 wt. %, FeO_T= 5.41-6.07 wt. %, TiO_2= 1.26-1.93 wt. %, and BaO= 0.93-2.11 wt. %. Overall, groundmass mica from Peter I and II are similar to PII microphenocryst mica with many samples showing enrichments in Fe and depletions in Ti relative to microphenocrysts. Groundmass micas from both Peter I and II represent the last stage in the mica evolution of this kimberlite, as they display the lowest, most Ti-depleted compositions relative to all other microphenocrysts.

Peter I Dark Brown Cored Microphenocrystal Micas

Exclusive to Peter I are rare, inclusion-free microphenocryst micas with dark brown cores mantled with colourless to pale yellow rims (Table 3.4, Fig. 3.10-3.12). The dark brown cores (mg= 43.57-63.06) are Fe-rich (16.51-29.64 wt. %) and Ti-rich (1.32-4.55 wt. %) with 12.31-14.83 wt. % Al_2O_3, and 0.04-0.24 wt. % BaO. Compared to the cores, the rims (Table 3.4, Fig. 3.11-3.12) are Fe-poor (5.00-11.26 wt. %), Al-rich (12.96-17.12 wt. %), Ti-poor (1.39-3.01), and Ba-rich (0.57-1.68 wt. %), similar to PII mica compositions.

Similar groundmass mica in orangeites (Group II kimberlites) from South Africa (north Cape Province and the western and eastern parts of the Orange Free State) and from an archetypal Group I kimberlite from the Upper Canada Mine, Kirkland Lake, Ontario were termed Type I mica by Smith et al. (1978). Smith et al. (1978) postulated that Type I micas may have been derived from a carbonatitic magma that subsequently mixed with the kimberlite magma. Mitchell and Meyer (1989a) noted the consistent association of Type I micas with orangeites and their absence (typically) in kimberlites, and suggested a genetic affinity of them with orangeite magmas. The presence of Type I mica in the Peter dyke may be best explained by mixing of carbonatite, rather than to a genetic affinity with orangeites, because the Peter dykes do not display typical mineralogical characteristics of orangeites.

Peter I Macrocryst/Phenocryst Mica

A single macrocryst/phenocryst from Peter I was analysed (Table 3.5) with individual point analyses for the core and rim plotted in Figure 3.13. Based on major element compositions (mg= 64.65-78.74, 12.55-14.47 wt. % Al_2O_3, 9.67-18.70 wt. % FeO_T, 1.82-2.75 wt. % TiO_2, and 0.42-1.18 wt. % BaO), the core is interpreted to be a xenocryst of unknown origin incorporated into the magma that was then overgrown by a primary PI mica rim. The rim (mg= 84.62-88.05, 14.25-16.35 wt. % Al_2O_3, 5.37-6.92 wt. % FeO_T, 2.45-3.24 wt. % TiO_2, and 0.46-1.29 wt. % BaO) is interpreted as being one of the earliest forming primary phases observed, based on its high TiO_2 content, and because it shows rounding, probably resulting from its subsequent ascent with the magma after crystallization.

Summary of Peter Micas

Figure 3.14 illustrates the major element compositional variations exhibited by mica from the Peter I and II kimberlite dykes. All microphenocryst cores and rims, and groundmass micas are phlogopites, intermediate between eastonite and phlogopite endmembers. Dark brown cored microphenocryst micas are biotites with solid solution between siderophyllite and annite, whereas associated rims are similar to microphenocrysts and groundmass phlogopites.

Overall, core-to-rim zoning of Peter I and II microphenocrystal phlogopites shows depletion of Ti accompanied with increasing Al (usually), or decreasing or constant Al. Fe-content generally decreases, however, constant to slightly increasing Fe was observed – these zoning trends are typical for kimberlite phlogopite (Mitchell, 1986, 1995b). The most pronounced Ti-depletion is within groundmass phlogopite from Peter I and II; this depletion in Ti represents the final stages of mica evolution in these kimberlite dykes. Some rare compositional variations are evident, as observed in Peter I and II microphenocrysts - Fe-contents can be substantially higher than normal with an associated lower mg value. Groundmass mica from Peter I also show an increase in Fe-contents, but all other major elements are consistent with PI and PII phlogopite compositions. Smith et al. (1978) attributed the varying compositions of micas to changes in the composition of the kimberlite magma on a mm scale. Mitchell and Meyer (1989a) argued that such a process will not result in compositionally distinct cores and rims, but rather mixing of magmas of slightly different compositions will result in compositionally distinct cores and rims.

Analysed micas from Peter I display compositionally distinct cores and rims. The boundaries between cores and rims are optically well defined suggesting that the rims are not reaction mantles resulting from a progressive change in the magma composition, but are the result of magma mixing. Chemical heterogeneities within cores and rims also are consistent with the existence of small scale differences in the bulk kimberlite magma existed, as well as possible magma mixing event(s). An alternative mechanism to explain the observed core/rim characteristics could result from a dramatic/abrupt change in magmatic conditions, such as varying conditions of pressure, temperature, or fO_2. Another mechanism could also involve a significant hiatus in phlogopite crystallization: cores crystallized early at which point phlogopite stops to crystallize for a time period then resumes at a later stage. Such a hiatus could explain the core/rim characteristics.

A possible scenario is illustrated in Figures 3.15 and 3.16 which display the variety of mica present in the Peter I and II dykes, and the possible crystallization sequence, respectively. Peter I contains three distinct varieties of mica. The least common micas are dark brown cored microphenocrysts (Type I mica) mantled by colourless to pale yellow rims. The remaining micas consist of microphenocryst and groundmass grains each with distinct compositions for cores and rims. Microphenocrysts may either consist of medium to pale yellow brown cores (PI) mantled by colourless to pale yellow rims (PII), or grains cored and mantled solely by micas of PII composition. Groundmass micas are optically and compositionally similar to PII rims which mantle micropheocrysts and Type I mica. A single macrocryst/phenocryst was also observed with a core of unknown origin mantled by PI mica. Peter II contains microphenocryst and groundmass mica that are compositionally similar to Peter I microphenocryst rims and groundmass mica (Fig. 3.15).

Mica crystallization began with the formation of PI micas, which are phlogopites (mg~ 81-86) with 14-15 % Al_2O_3, 6-7 % FeO_T, and ~ 3 % TiO_2 [Fig. 3.16A]). En route to surface a magma mixing event occurred, or an abrupt change in magmatic conditions (P-T-fO_2), which induced the crystallization of PII micas (Fig 3.16B,C). PII micas are phlogopites (mg~ 86-89) with 16-17 % Al_2O_3, 5-6 % FeO_T, and ~ 2 % TiO_2. Evidence to support magma mixing comes from the presence of Type I micas, with corroded cores (Fig. 3.10). The newly introduced Type I micas are subsequently mantled by PII mica (Fig. 3.16D). The composition of the magma that was host to these micas is unknown, but probably was similar to that of the Peter magma. Large differences in the bulk compositions of the two magmas would lead to micas crystallizing with anomalous compositions divergent from that observed for kimberlites in general; such divergent geochemistries were not observed. Lastly, crystallization of groundmass micas occurred (Fig. 3.16E). Peter II consequently may represent a portion of the magma which only crystallized PII mica as there is no evidence for PI micas (Fig. 3.16C*-E*).

Spinel

Spinels from Peter I and II are petrographically similar and occur as opaque subhedral-to-euhedral microphenocrysts and groundmass crystals (0.3-0.016 mm) set within the groundmass. Atoll textures are observed but are uncommon. As mentioned previously, grains may be associated with olivine as single crystals or as a necklace surrounding grain margins.

Inclusions of spinel occur in microphenocrystal phlogopite and macrocrystal and microphenocryst olivine.

Representative spinel analyses are given in Table 3.6 with spinel endmembers calculated based on the method described by Mitchell and Clarke (1976). It should be noted that not all presented analyses have all endmembers, because Mitchell and Clarke's (1976) method fails for the majority of analysed atolls and rims in which there is insufficient Ti to carry out the calculation. Mitchell and Clarke's (1976) method does not define the order in which endmembers are calculated, which limits the utility of this method because there is no single "right" answer. Nevertheless, endmember compositions were used in this study purely for comparison reasons.

Spinels are present as both chemically zoned and unzoned crystals, some mantled by atolls. All cores analysed are members of the magnesian ulvöspinel-ulvöspinel-magnetite series. Rims and atolls are Ti-bearing magnetites, which are Ti, Mg, and Cr-depleted, and Fe-enriched relative to cores. From core to rim to atoll, Ti, Al, and Mg decrease, whereas total Fe, Fe^{3+}/Fe^{2+}, $Fe_T/(Fe_T+Mg)$, and Mn-content increase. A single titaniferous-magnesian aluminous chromite was analysed (Table 3.6, anal. TIMAC)

The spinel compositional/evolutional trends observed in archetypal kimberlites are unique, providing a discriminant between kimberlites and petrographically similar lamproites and orangeites (Mitchell, 1986, 1995b). In the reduced spinel prism (Fig. 3.17) three compositional trends are observed: (1) Aluminous magnesian chromite trend (AMC); (2) Magmatic Trend 1, or magnesian ulvöspinel trend; and (3) Magmatic Trend 2, or titanomagnetite trend. Magmatic Trend 1 is the characteristic spinel compositional trend unique to kimberlites, of which, spinels of this group contain 12-23 wt. % TiO_2, 12-20 wt. % MgO, and 20-40 mol. % of the Mg_2TiO_4 (magnesian ulvöspinel) molecule (Mitchell, 1986, 1995b). The trend begins near the base of the prism close to the $MgCr_2O_4$-$FeCr_2O_4$ join [commonly Cr/(Cr+Al)= 0.80-0.95, and $Fe_T/(Fe_T+Mg)$= 0.40-0.60], and evolves with progressively lower Cr/(Cr+Al) toward the rear face of the prism and upwards to the Mg_2TiO_4-Fe_2TiO_4 apex (Mitchell, 1995b). Kimberlites spinels evolve from titanium aluminous chromites (TIMAC) or titanian magnesian chromites (TMC) containing 1-12 wt. % TiO_2 towards magnesian ulvöspinel-ulvöspinel-magnetite solid solutions (MUM) with ≥ 15 wt. % TiO_2 – the trend culminates with the formation of Ti and Mg-free magnetite (Mitchell, 1986, 1995b). Compositionally, from TIMAC or TMC to MUM there is increasing Ti, total Fe, Fe^{3+}/Fe^{2+}, with decreasing Cr at approximately constant $Fe_T/(Fe_T+Mg)$

(Mitchell, 1986, 1995b). Magmatic Trend 2 spinels are uncommon in archetypal kimberlites, however, orangeites spinels exhibit compositional trends identical to Trend 2 – they do not contain significant quantities of the Mg_2TiO_4 endmember (10-20 wt. %) [Mitchell, 1995b].

Spinels for Peter do not span the entire compositional range of spinels as outlined above. In any given, kimberlite this trend is not always fully developed; some kimberlites contain only the initial, least evolved, Cr-rich portion of the trend, whereas others contain the most evolved portion; Ti-rich and Cr-poor spinels (Mitchell, 1986). Peter spinels belong to the later group, displaying evolved Ti-rich, Cr-poor spinels, although a single TIMAC was observed. Peter rims and atolls are approaching the final stages of spinel evolution with the development of Ti and Mg-free magnetite. This is evident in their low TiO_2 (~ 8 wt. % for rims, and ~ 7 wt. % for atolls), low MgO (~ 8 wt. % for rims/atolls), and high FeO_T (~72 wt. % for rims, and ~ 73 wt. % for atolls) relative to MUM cores. Mitchell (1986) also noted that MnO contents in kimberlite spinels are typically < 1.0 wt. % but may slightly increase in evolved spinels. The least evolved spinel in Peter was a single TIMAC crystal with 0.36 wt. % MnO. Mn-contents progressively increase from MUM cores (0.56-0.86 wt. %) to rims (0.84-2.01 wt. %) to atolls (0.87-2.29 wt. %). These high Mn-contents further support the evolved character of the Peter spinels.

Plotted in Figures 3.18 and 3.19 are individual point analyses for Peter spinel cores, rims, and atolls. Figure 3.18 is a plot from the front face of the reduced spinel prism which outlines the generalized compositional fields for Magmatic Trend 1 and 2 spinels. The bulk of the analysed spinels plot between Trends 1 and 2, and the remaining rims and atolls plot within Trend 2. Average values for Ti/(Ti+Cr+Al) differ for cores (0.705) compared to rims and atolls, which are essentially identical (0.566 and 0.553, respectively). Cores have an average $Fe_T/(Fe_T+Mg)$ of 0.733 with rims (0.834) and atolls (0.873) having similar values, but greater than that for cores. Figure 3.19 illustrates that low Cr/(Cr+Al) is typical for cores, rims, and atolls (0.016, 0.021, and 0.005 respectively). All Cr-bearing grains analysed with the exception of the single TIMAC grain (Figs. 3.18B and 3.19B) are compositionally similar to Peter cores.

Based on Figure 3.18 it could be argued that Peter spinels are not kimberlitic, which preclude the Peter dykes from being kimberlites. The counter argument is that all analysed cores contain substantial proportions of the magnesian ulvöspinel molecule (~ 26 mol. %), high TiO_2 (~ 18 wt. %) and MgO (~ 12 wt. %) contents, which are indicative of a kimberlitic origin.

Groundmass

The groundmass is relatively homogenous in appearance, and is composed of clear massive anhedral-to-subhedral interlocking fractured carbonate, with a dirty brown appearance (Fig. 3.3B). The carbonate is a ferroan dolomite in composition (Ca-Mg-Fe; based on semi-quantitative EDS analyses), and is interpreted to be primary. Primary dolomite in kimberlites is rare and is generally an accessory phase (Mitchell, 1986 and references therein). The Peuyuk C kimberlite, Somerset Island, is another kimberlite that contains primary groundmass dolomitic carbonate (Clarke and Mitchell, 1975). More commonly however, dolomite forms as a secondary phase. Scott Smith et al. (1984) have shown that alteration of magmatic clear euhedral interlocking calcite crystals from the Orroroo kimberlite, South Australia, formed a fine grained, sugary dolomite. Minor calcite is present as submicron veinlets and discrete patches within Peter. Scattered throughout the groundmass, are subhedral-to-euhedral (< 0.005 mm) apatite grains, subhedral-to-anhedral barite, and Fe-Ni and Fe sulphides, visible using backscatter electron imaging on the electron microprobe. Modally, these phases are negligible.

Mineralogy and Mineral Chemistry of K-L 2A and 2B Dykes

A second set of kimberlite dykes (K-L) will now be discussed. These kimberlite dykes are mineralogically similar to Peter with the exception of the absence of phlogopite.

Olivine

Olivine occurs in two generations with sizes varying from 0.15-4.5 mm with an average grain size of 0.45 mm. Macrocryst olivines are rounded-to-anhedral, whereas phenocryst/microphenocryst olivines are subhedral-to-euhedral. Pervasive alteration pseudomorphs all grains with a yellow alteration product identical to that observed in the Peter dykes. Carbonate alteration also occurs and typically appears as blebs or finger-like emanations within grains. A second style of alteration is a very fine grained, sugary dirty brown carbonate, similar to groundmass material, which replaces and crosscuts grains and is interpreted to be a secondary alteration product. As a result of the alteration, the morphology of the grains has been modified, rendering distinction of the two paragenesis of olivine impossible in some samples. Inclusions are present within grains and generally consist of spinel (typically Cr-rich); a single Cr-diopside inclusion was also observed. Necklaces of spinel may surround grains, and altered olivine phenocryst/microphenocrysts display a weak to moderate flow alignment.

Spinel

Spinels from all samples examined are opaque, subhedral-to-euhedral, 0.4-0.008 mm microphenocryst and groundmass phases. Atoll-textured spinels are a common feature. The gap present between cores and atolls is occupied by carbonate and(or) an alteration material identical in appearance and composition to that pseudomorphing the olivine grains. The atolls are spongy and irregular, so the quality of analyses of these regions was poor. The spinels are not uniformly distributed throughout the groundmass, and there appears to be in some instances a preferred association of spinels with the massive, fine-grained sugary dark brown groundmass material.

Analysed spinels (Tables 3.7 and 3.8; Figures 3.20-3.22) are compositionally homogenous, most belonging to the MUM solid solution series with ~ 21-22 mol. % of the Mg_2TiO_4 endmember – seven TIMAC crystals were analysed in K-L 2A (4) and K-L 2B (3). A single TIMAC from the K-L 2B dykes occurred as an inclusion within an olivine grain, implying that TIMAC spinels were the first spinels to crystallize. As was the case with Peter spinels, no analyses plot within the Magmatic Trend 1 field, but between Trends 1 and 2 (Fig. 3.20). Cores from K-L 2A and 2B have consistent and similar average $Fe_T/(Fe_T+Mg)$ of 0.729 and 0.734 respectively, likewise, for Ti/(Ti+Cr+Al) [0.546 and 0.536; Fig. 3.20]. Low Cr/(Cr+Al) are also observed for K-L 2A (0.012) and K-L 2B (0.017) cores (Figs 3.21, 3.22). Cr-bearing MUM samples (Figs. 3.20B, 3.21B, and 3.22B) are compositionally similar to cores.

The composition of atolls from K-L are richer in Al, Mg, and Mn, and poorer in Ti and total Fe relative to K-L cores. Atolls from K-L 2A and 2B have broadly similar average $Fe_T/(Fe_T+Mg)$ [0.680 and 0.632 respectively], Ti/(Ti+Cr+Al) [0.546 and 0.536], and Cr/(Cr+Al) of 0.001 for each. The overall zonation from core-to-atoll is of increasing Mg, Al, Mn, and Fe^{3+}/Fe^{2+}, with decreasing total Fe, Ti, and $Fe_T/(Fe_T+Mg)$.

Summary of Peter and K-L Spinels

Most of the Peter and K-L spinels are Ti-rich and Cr-poor bearing spinels, which are characteristic of evolved kimberlite spinels. Crystallization began with the formation of TIMAC spinels in the Peter and K-L dykes. Subsequent to this, TIMAC spinels were either physically separated from the magma, or resorbed, explaining their extremely low abundance. The magma continued to crystallize spinel grains that were progressively evolving relative to the bulk of the spinels observed in the two dykes; i.e., compositionally towards MUM spinels. The intermediate spinel phases between TIMAC and MUM were either removed or resorbed (similar to TIMAC), or never crystallized (based on their absence in the dykes). Many other kimberlites do not show a continuous series of solid solutions between TIMAC/TMC and MUM compositions, which may indicate the presence of a solvus in this system (Mitchell, 1986). The hiatus in spinel crystallization observed in the Peter dykes may be explained in this fashion. The last spinels to crystallize in the Meliadine dykes were atoll spinels.

MUM cored spinels are characteristic in both dykes, however, there are differences with respect to major element compositions. Spinel cores in Peter have lower average Al_2O_3 (5 wt. %) and higher average TiO_2 (19 wt. %), compared to K-L cores with 9 wt. % Al_2O_3 and 16 wt. % TiO_2. This lower Al in the Peter spinels is consistent with the presence of phlogopite in Peter and its absence in K-L. Mitchell (1978) found that spinels from non mica-bearing kimberlites were enriched in Al relative to phlogopite bearing kimberlites containing spinels of similar Ti-content.

Chemical zoning of spinel grains is only observed in the Peter dykes, with a decrease in Ti, Al, and Mg, and an increase in total Fe, Fe^{3+}/Fe^{2+}, $Fe_T/(Fe_T+Mg)$, and Mn-content from MUM cores to Ti-bearing magnetite rims and atolls. K-L spinels consist of unzoned MUM cores ± atolls that are enriched in Al, Mg, and Mn, and depleted in Ti and total Fe relative to K-L cores. This zonation trend is unusual in that progressively evolving spinels should culminate in the formation of Ti and Mg-free magnetite (Mitchell, 1995b). This highly-evolved magnetite composition is being approached in the Peter dyke, however, spinel evolution in K-L has been interrupted. K-L atolls are Ti poor and have higher Fe^{3+}/Fe^{2+} than their associated MUM cores – this is consistent with typical spinel evolution. What is atypical is increasing MgO and decreasing total Fe, as evident in the lower $Fe_T/(Fe_T+Mg)$; opposite to what is expected. A definitive explanation to this discrepancy requires better quality data on the atoll.

Apatite

Apatite occurs as a subhedral-to-euhedral groundmass phase present in ≤ 1 vol. % of any given slide examined. Hexagonal cross-sections are common (~ 0.16 mm diameter), as are prismatic sections that typically show fracturing normal to edges. Carbonate alteration along the fractures occurs infrequently.

Analyses of apatite was exclusively from K-L 2B (poor analyses from K-L 2A, Table 3.9). All grains are relatively homogenous in major elements, with 2.65-4.53 wt. % SiO_2 replacing phosphorous. Minor amounts of Sr, REE (La, Ce, and Nd), and F are present. Analyses from other kimberlites for comparison are very limited, but they are essentially very pure fluor-hydroxy apatites with minor amounts of SiO_2 (ca. 2.0 wt. %) replacing phosphorous

(Mitchell, 1986, 1989). Comparison with apatites from other potassic alkaline rocks such as orangeites and lamproites is difficult, in that apatites from these rocks are poorly characterized. Apatite from orangeites are typically richer is SrO (> 1 wt. %) and may have significant Si replacing phosphorous, as with kimberlite apatite – abundances of REE are similar (Mitchell, 1995b). Lamproite apatites are fluor-apatites (2-7 wt. % F) characterized by high SrO (1-6 wt. %), and generally low SiO_2 (typically < 1 wt. %), consequently, they are compositionally similar to apatite occurring in orangeites [Mitchell, 1995b].

K-L apatites, relative to those in other kimberlites, orangeites, and lamproites, are silica-rich and fluorine-poor. These are significant geochemical differences; on the other hand, characterization of apatites occurring in potassic alkaline rocks is at an early stage, and therefore K-L apatites may prove to be closer to the norm once more data is presented.

Groundmass

Modal abundances of groundmass material can vary widely between thin sections, and in all examined sections, this material always dominates modally. Two styles of groundmass occur (Gm1 and Gm2), of which either style may dominate in a particular region, or the whole slide (Figs. 3.2A and 3.23). The first type (Gm1), is a light-to-medium, fine grained, sugary brown-grey, optically unresolvable material that appears primary in origin. A secondary version of GM1 material exists; texturally it appears as veins that cross-cut and replace olivine grains. Gm1 material may be solely composed of Ca-Mg-Fe carbonate (ferroan dolomite) or a mixture of this carbonate with calcite ± high Fe-bearing serpentine identical to that found within altered olivine grains. In contrast, Gm2 material is essentially clear irregularly shaped patches or lath-shaped blebs of varying sizes composed of massive-to-anhedral interlocking calcite. Although calcite is the dominant material in this groundmass, clear dolomite also occurs rarely. Segregation textures occur throughout the groundmass and are composed of Gm2 material (Fig. 3.2A).

The origin of segregations within kimberlites is controversial, and several hypotheses have been proposed (Mitchell, 1986 and references therein): liquid immiscibility; gas condensates within vesicles; and filling of vesicles by a residual carbonate-rich liquid. Segregation textures observed in K-L may represent silicate-carbonate liquid immiscibility. GM1 groundmass material may have been a silicate-carbonate liquid that co-crystallized silicate minerals (spinel, apatite, high Fe-bearing serpentine) and carbonates (dolomite and calcite). Later separation of the carbonate fraction yielded GM2 material. Alternatively, the silicate-carbonate liquid may have evolved towards a carbonate-rich residua; silicate + carbonate minerals co-crystallized with a continued evolution of the magma towards a carbonate-rich composition. This eventually lead to the formation of GM2 material.

Also present in the groundmass are cross-cutting late stage calcite veins and minor sub-mm veins consisting of similar material of that of altered olivines. Extremely fine grained subhedral-to-anhedral barite (< 0.005 mm) and pyrite were identified using EDS on the electron microprobe.

Megacrysts and Macrocrysts

Mantle-derived megacrysts and macrocrysts are absent from all examined sections from the Peter and K-L dykes. Separation of a heavy mineral fraction from Peter (0.57 kg), K-L 2A (0.86 kg), and K-L 2B (0.86 kg) yielded a total of 13 garnet microcrysts/xenoliths (ten from Peter and three from K-L 2A and 2B), and perovskite from K-L 2B.

Garnet

All recovered garnets are between 0.35-0.77 mm and are rounded-to-irregularly shaped. Garnet compositions are given in Table 3.10. All samples were classified using the statistical method of Dawson and Stephens (1975). Of the 12 groups of garnet defined by Dawson and Stephens (1975), three were recognized from the processed samples (Table 3.10 anal. G1, G5, G11): Group 1-Titanian pyrope; Group 5-Magnesian almandine; and Group 11-Titanian uvarovite pyrope.

The bulk of the garnets (ten Group 5) are high FeO (28.52-38.60 wt. %), MgO (1.26-9.92 wt. %) almandines, with one high MnO (13.00 wt. %) spessartine (Table 3.10, anal. 3). Such garnets are typically derived from acid igneous rocks, granulites and eclogites (metamorphosed crustal basement), and metamorphosed argillaceous sediments and pelitic rocks (Deer et al., 1982). Therefore, they are of no significance or interest with respect to kimberlites. The remaining three garnets are pyropic, which are common in garnet pyroxenites, garnet peridotites, eclogites, kimberlites, and diamond inclusions (Deer et al., 1982).

Two garnets from the Peter dyke fall into Dawson and Stephens (1975) group 11 (Table 3.10 anal. 1-2). These garnets are titanian uvarovite-pyropes with high TiO_2 (0.49-0.52 wt. %), high Cr_2O_3 (7.04-7.08 wt. %), and mg of 0.85, and are thought to be derived from megacrysts. These titanian uvarovite-pyropes are similar to Cr-rich garnet megacrysts from Fayette, County, Pennsylvania (mg= 0.81-0.85, 1.64-6.14 % Cr_2O_3, and 0.36-0.68 % TiO_2, Hunter and Taylor, 1984), and Cr-rich megacrysts from Colorado-Wyoming kimberlites (mg= 0.84-0.82, 6.3-13.0 % Cr_2O_3, and 0.22-0.94 % TiO_2, Eggler et al., 1979). These Cr-rich garnet megacrysts are compositionally similar to garnets derived from sheared and granular garnet lherzolite xenoliths (Fig. 3.24) found within the same kimberlites (Eggler et al., 1979; Hunter and Taylor, 1984). Nevertheless, Eggler et al. (1979) and Hunter and Taylor (1984) did not consider the Cr-rich megacrysts to be derived by disagregation of the garnet lherzolite xenoliths, because the garnet megacrysts are much larger (0.5-3.0 cm) than garnets occurring in the xenoliths (< 4 mm). Rather, they suggest that the Cr-rich megacrysts have crystallized from a proto-kimberlitic melt at depths of 150-200 km and high-T (1100-1300 °C). Based on the size of the Peter high-Cr garnets (< 0.77 mm) and lack of peridotitic xenoliths, a definitive origin for these grains cannot be determined.

A single garnet from the K-L dyke (Table 3.10 anal. 10) is a titanian pyrope with high TiO_2 (0.54 wt. %), 1.06 wt. % Cr_2O_3, and mg of 0.77 (Fig. 3.24). Compositionally, this titanian pyrope is similar to low-Cr megacryst garnets from Colorado-Wyoming kimberlites (mg= 0.68-0.84, 0.03-4.80 % Cr_2O_3, and 0.23-1.30 % TiO_2, Eggler et al., 1979), and is considered to be part of the Cr-poor megacryst suite (discrete nodule suite): titanium bearing pyropes (0-1.5 % TiO_2), with variable Cr_2O_3 (0-3 %) and mg (0.68-0.86) [Mitchell, 1986]. Cr-poor megacryst such as those from Colorado-Wyoming and K-L are considered to have crystallized from a fractionating magma at high pressure; at or below the lithosphere-asthenosphere boundary (Mitchell, 1995b and references therein).

Perovskite

Abundant fine grained (0.025-0.050 mm) subhedral-to-euhedral pinkish-rose groundmass perovskites were recovered from the K-L 2B dyke. Chemical analysis were not carried out on the grains, however, approximately 400 grains were hand picked for U-Pb geochronology (cf. Chapter 5).

Diamond Potential Of The Meliadine Kimberlites

The diamond potential of the Meliadine kimberlites may be assessed by the presence of certain key diamond indicator minerals, namely Cr-pyrope garnet, pyrope-almandine garnet, chromite, and ilmenite. Diamond potential is correlated (potentially) with the amount of diamond-bearing peridotite or eclogite sampled and entrained in the kimberlite during ascent, to the diamond grade of the source rocks themselves, and lastly, to how well the diamonds are preserved while en route.

The peridotitic paragenesis for diamonds can be subdivided into three potentially diamondiferous sources with the relative importance of the source with respect to diamond listed in decreasing order: garnet harzburgite, chromite harzburgite, and garnet lherzolite (Gurney, 1984). The content of diamonds derived from garnet harzburgite can be evaluated by the presence of low-Ca, high-Cr garnets. Such garnets have been termed G10 harzburgitic garnets, while lherzolitic garnets are referred to as G9-garnets. One is able to therefore distinguish between garnets derived from typically diamond barren lherzolitic sources, to those of potentially diamondiferous harzburgitic sources.

Incorporation and disaggregation of potentially diamond-bearing chromite harzburgite can be evaluated by the presence of chromite in much the same manner as garnet is used in discriminating between potentially diamond-bearing garnet harzburgite, to typically diamond barren garnet lherzolite. Chromites associated with diamonds are characterized by low TiO_2 (typically < 0.3 wt. %), high average Cr_2O_3 (> 60 wt. %), and moderate to high MgO (~ 12-16 wt. %) [Fipke et al., 1995].

The eclogitic paragenesis for diamonds has been divided into two distinct varieties. McCandles and Gurney (1989) defined Group I eclogites as chemically and texturally homogenous with enrichments of Na_2O in garnet (≥ 0.09 wt. %) and K_2O in clinopyroxene (≥ 0.08 wt. %), while Group II eclogites lack such enrichments. Average Na_2O in garnet and K_2O in clinopyroxene from diamondiferous eclogites and Group I eclogites are similar, and therefore suggest that Group I eclogites formed under the prerequisite conditions for diamond formation (McCandles and Gurney, 1989). Recently, the use of sodium contents in garnets to predict diamond potential has been called into question, based on the fact that there is no sensible way at defining a meaningful sodium content in garnet which uniquely characterize eclogite diamond facies conditions (Grütter and Quadling, 1998).

Upon sampling of a diamond-bearing source region, the incorporated xenolithic material must travel from the source to the surface, during which oxidation and resorption of the entrained diamonds may occur. Diamond stability is based on P-T-fO_2, therefore, if equilibria is altered during ascent in the host magma resorption (complete/partial) of the entrained diamond will occur, or burn if conditions are excessively oxidizing. Diamond preservation may be judged using ilmenite composition, which appear to give some measure of redox conditions in the kimberlite magma (Fipke et al., 1995 and references therein). Highly oxidizing and thus low diamond preservation are associated with low MgO ilmemite (and high Fe^{3+}/Fe^{2+}), while low Fe^{3+}/Fe^{2+} (i.e., depleted in the Fe_2O_3 [hematite] component) indicate more favourable diamond preservation conditions; high Cr^{3+} can be present in either association (Fipke, et al., 1995).

Schulze et al., (1995) however demonstrated that "no evidence has been found to support the hypothesis that oxidized ilmenite populations correlate with increased potential for diamond resorption in a given kimberlite."

The few garnets (thirteen) recovered from the dykes were dominantly crustal derived (ten), along with two high-Cr megacryst garnets, and a single low-Cr megacryst garnet (a member of the discrete nodule suite), but no G10-garnets, or garnets of eclogitic affinity. The presence of the Cr-rich and Cr-poor megacryst garnets do however indicate a mantle origin, suggesting that the Meliadine kimberlites were derived from regions of elevated P-T (~ 150-200 km at or below the lithosphere/asthenosphere boundary) [Eggler et al., 1979; and Hunter and Taylor, 1984 and references therein; Mitchell, 1995b and references therein].

The parental magma(s) to the Meliadine dykes may have sampled potentially diamondiferous peridotite and eclogite, however, until the indicators associated with these dykes are identified, the diamond potential of the Meliadine dykes is extremely low. This is not to say that the Meliadine Trend, the Archean supracrustal rocks of the Rankin Inlet Group, and the Churchill Province as a whole are unsuitable environments for diamonds. Kimberlites rarely occur as discrete intrusions, but commonly occur in clusters, and therefore, further exploration will likely define potentially economic diamond-bearing kimberlites.

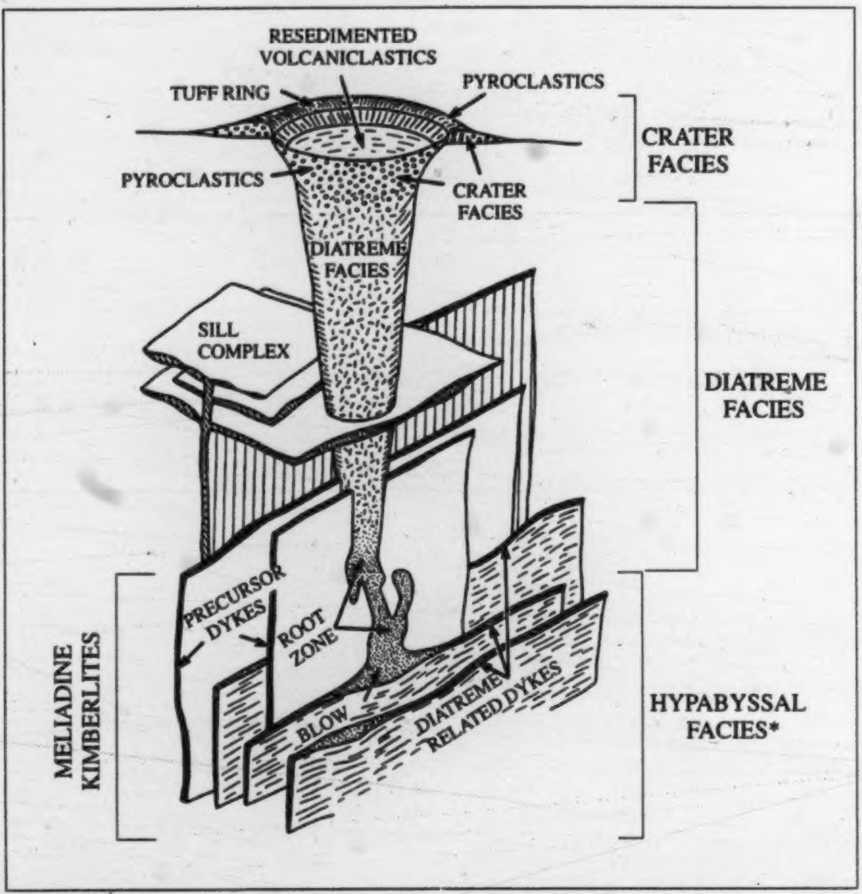

RESEDIMENTED
VOLCANICLASTICS
TUFF RING
PYROCLASTICS
PYROCLASTICS
CRATER
FACIES
CRATER
FACIES
DIATREME
FACIES
SILL
COMPLEX
DIATREME
FACIES
PRECURSOR
DYKES
ROOT
ZONE
BLOW
DIATREME
RELATED DYKES
MELIADINE
KIMBERLITES
HYPABYSSAL
FACIES*

Figure 3.1. Generalized model for an idealized kimberlite magmatic system (not to scale) displaying crater facies, diatreme facies, and hypabyssal facies* (includes sills, dykes, root zone, and "blow") rocks. Also shown is the generalized location of the Meliadine kimberlites (modified from Mitchell, 1986).

Figure 3.2. K-L kimberlite (A, B, C). Altered microphenocryst olivine (O) and microphenocrysts and groundmass spinel (S). The groundmass consists of a fine-grained sugary brown-grey optically unresolvable material composed of Ca-Mg-Fe carbonate ± calcite and(or) high Fe-bearing serpentine (designated by arrow-1). A second style of groundmass (arrow-2) consists of clear irregularly shaped patches or lath-shaped blebs of varying sizes composed of calcite.

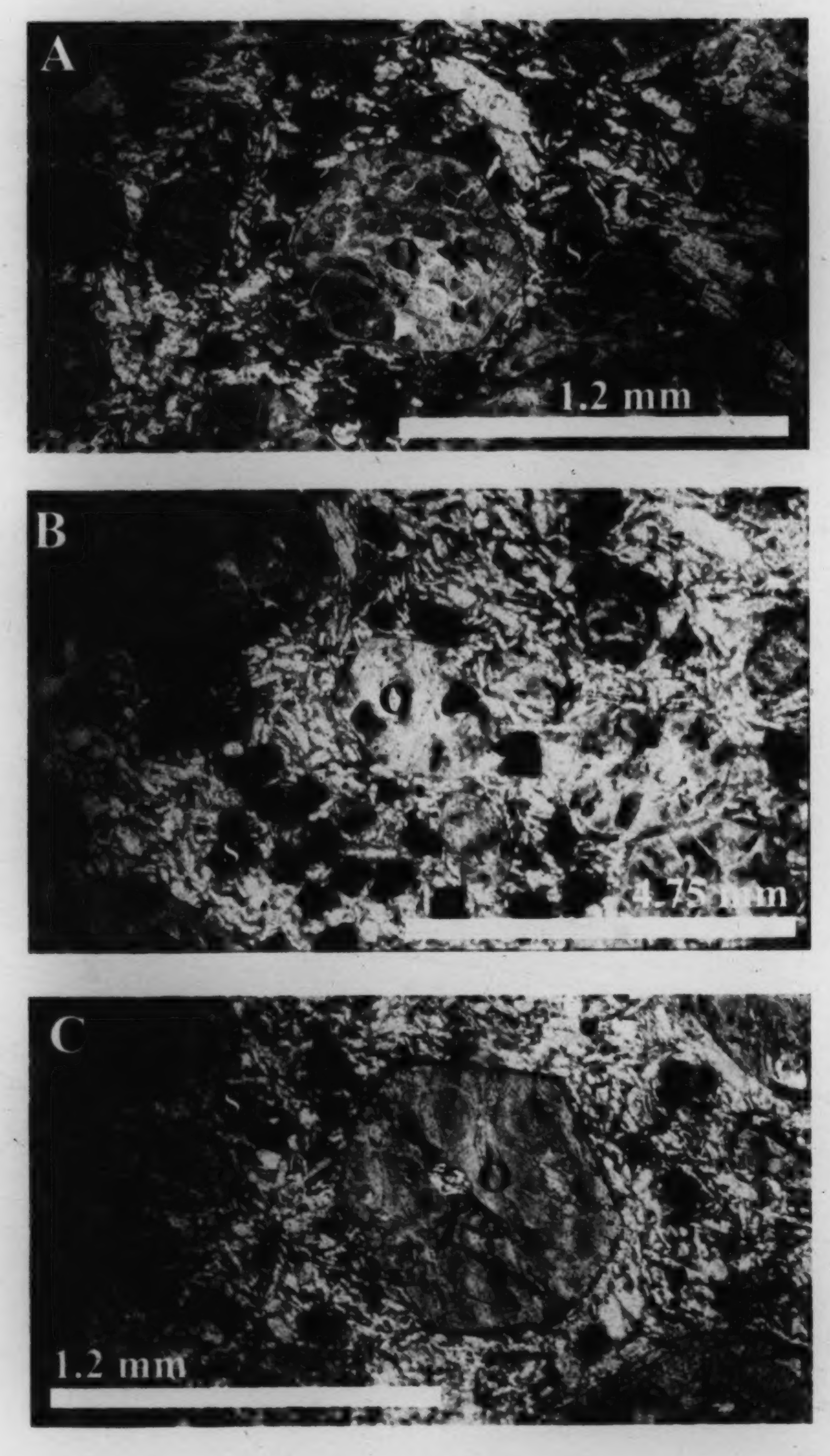
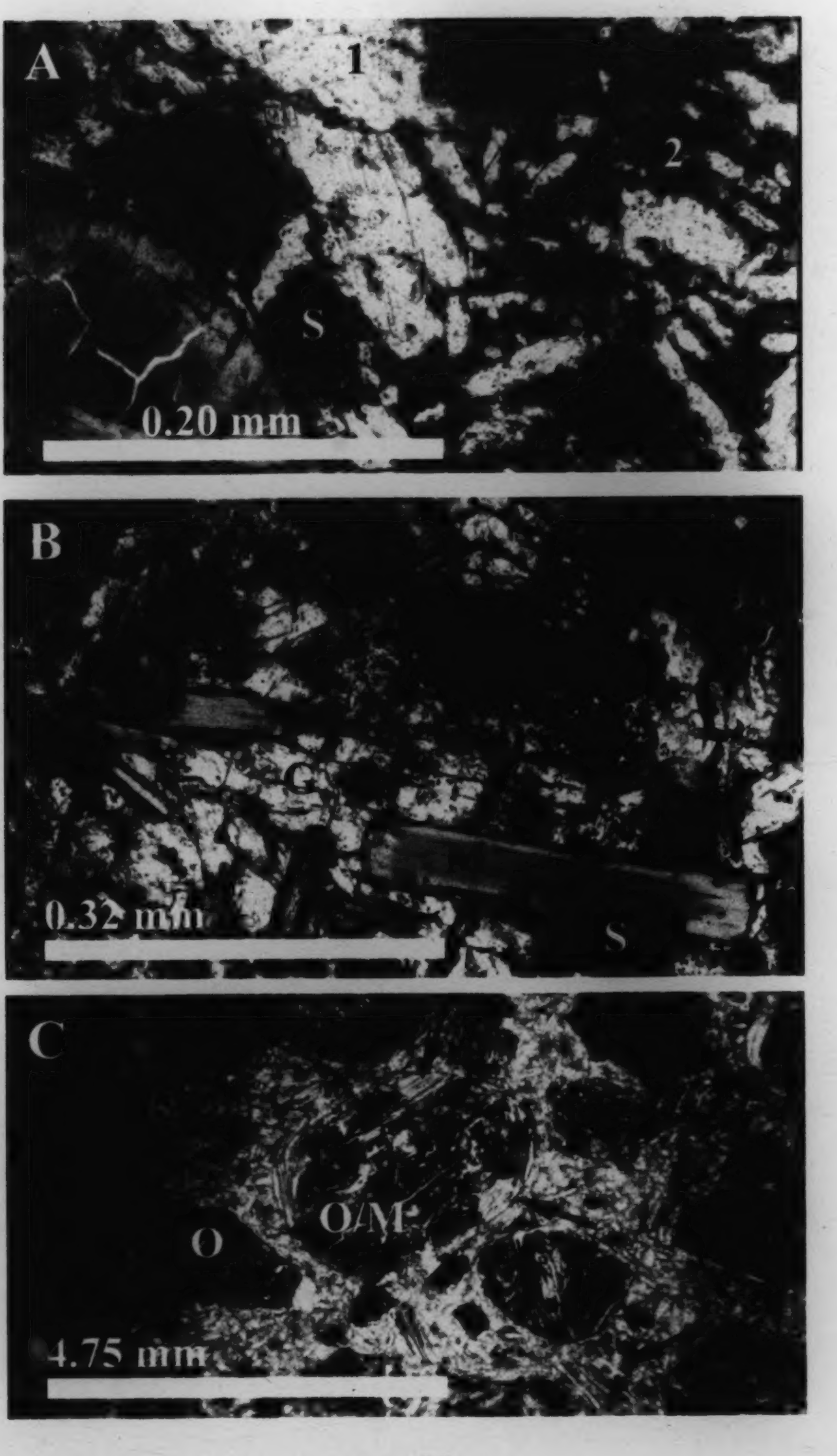

A
S
1.2 mm
B
Q
S
4.75 mm
C
S
Q
1.2 mm

Figure 3.3. Close up of K-L groundmass carbonate (1 clear groundmass, 2 sugary groundmass; see Fig. 3.2 for explanation of groundmass types) and altered olivine microphenocrysts (O), and microphenocryst and groundmass spinel (S) [A]. Peter kimberlite (B, C) displaying microphenocryst and groundmass spinel (S). Microphenocryst phlogopite (M) displays zonation with pale yellow-brown cores overgrown by a pale yellow rim; groundmass grains also present in left of Figure 3.3 B. Phlogopite also may mantle olivine (O/M) with phlogopite denoted by arrows (C). Peter groundmass (G) is composed of clear massive anhedral-to-subhedral interlocking fractured Ca-Mg-Fe carbonate, with a dirty brown appearance.


A
1
2
S
0.20 mm
B
C
S
0.32 mm
C
O
O/M
4.75 mm

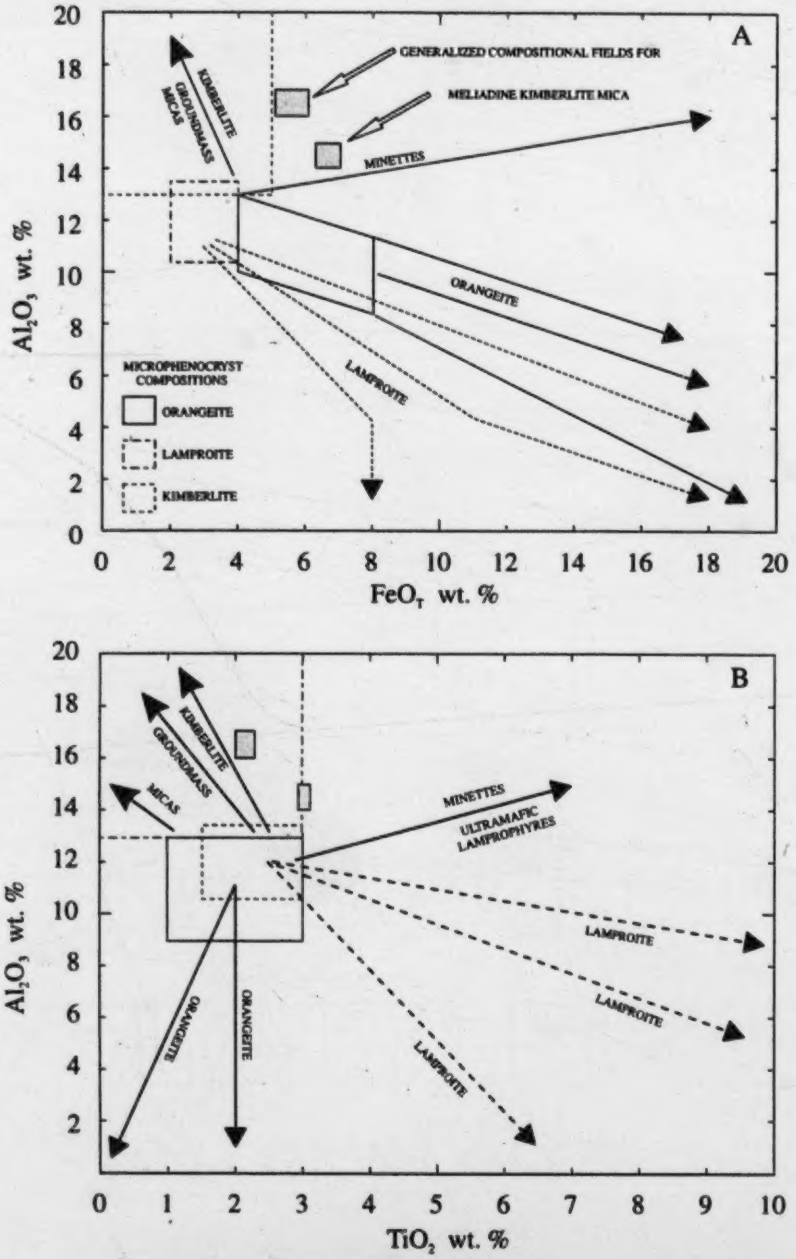


Figure 3.4. Al_2O_3 versus FeO_T (A) and TiO_2 (B) compositional variation and mica evolutionary trends of mica from kimberlites, orangeites, lamproites, and minettes/ultramafic lamprophyres (modified from Mitchell 1995b). Also displayed are generalized compositional fields for Meliadine kimberlite micas (this work).

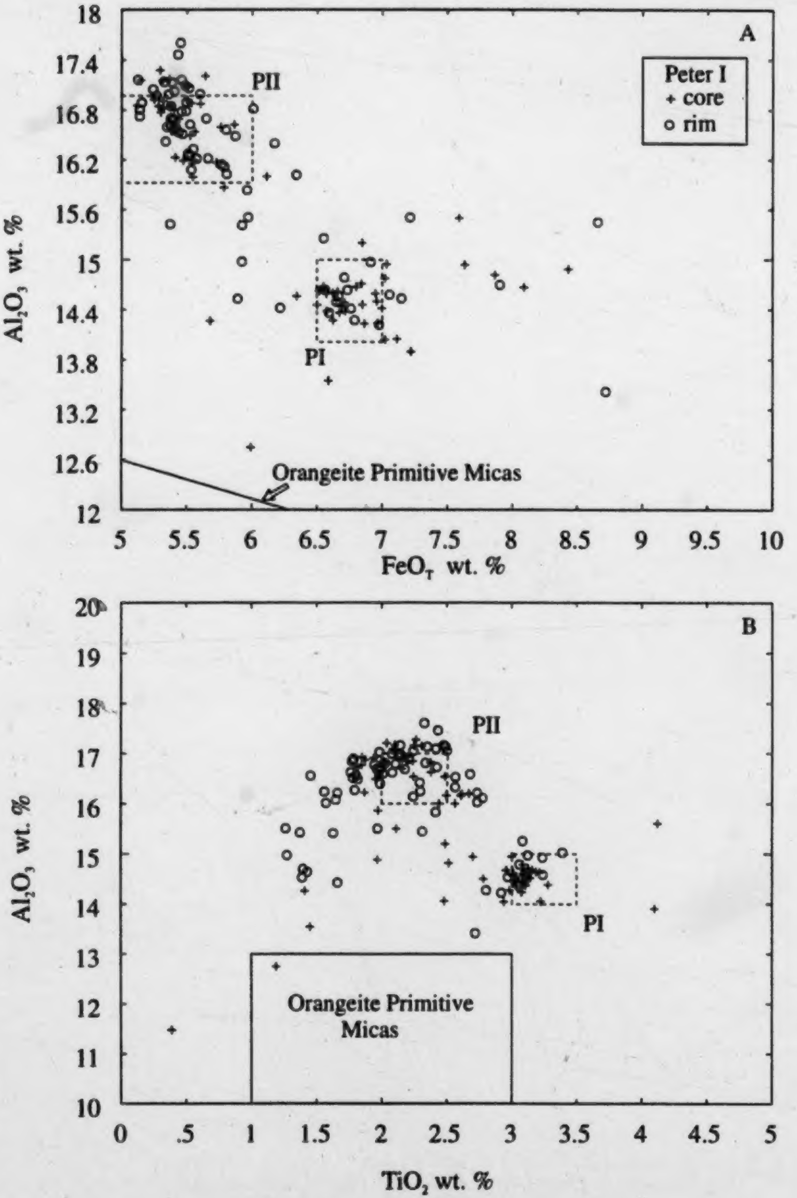


Figure 3.5. Al_2O_3 versus FeO_T (A) and TiO_2 (B) compositional variation of individual point analyses of microphenocryst cores and rims in the Peter I kimberlite. Orangeite primitive mica fields from Mitchell (1995b), and generalized boxed regions for Population I (PI) and II (PII) micas (this work).

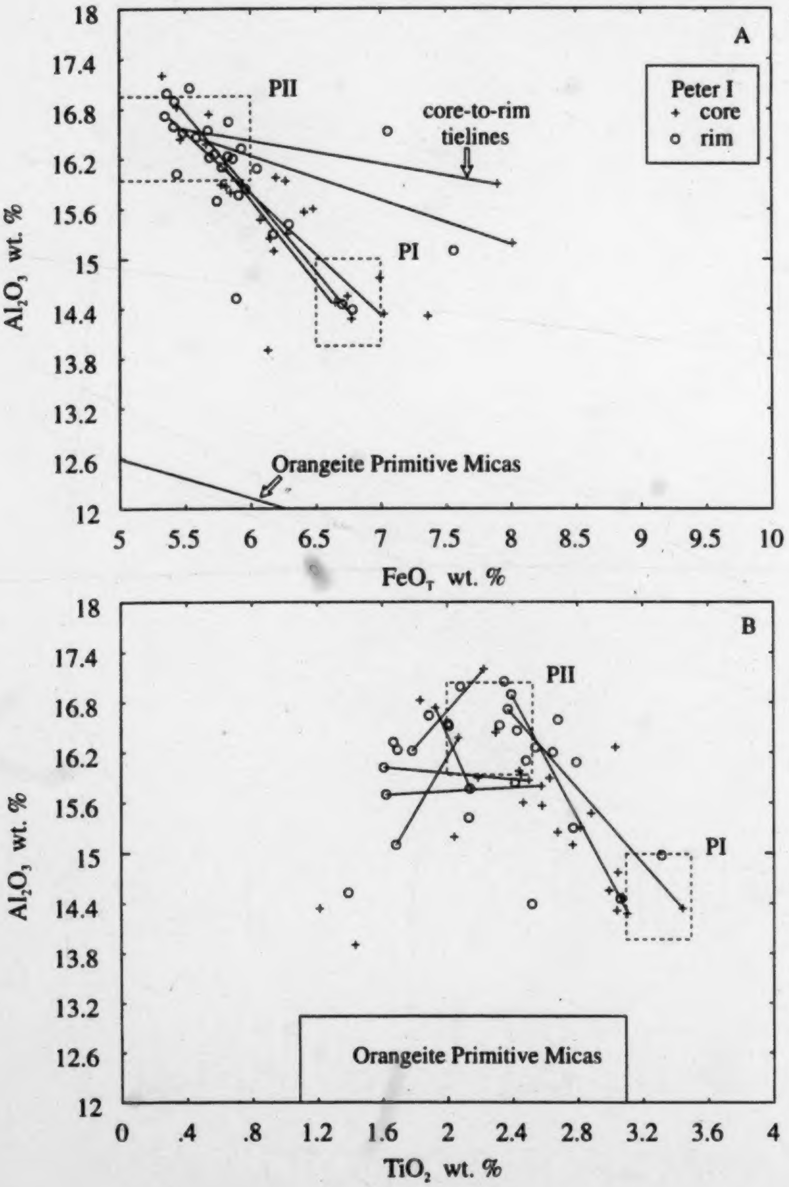


Figure 3.6. Al_2O_3 versus FeO_T (A) and TiO_2(B) compositional variation of averaged point analyses of microphenocryst mica cores and rims in the Peter I kimberlite. Orangeite primitive mica fields from Mitchell (1995b), and generalized boxed regions for Population I and II micas (this work).

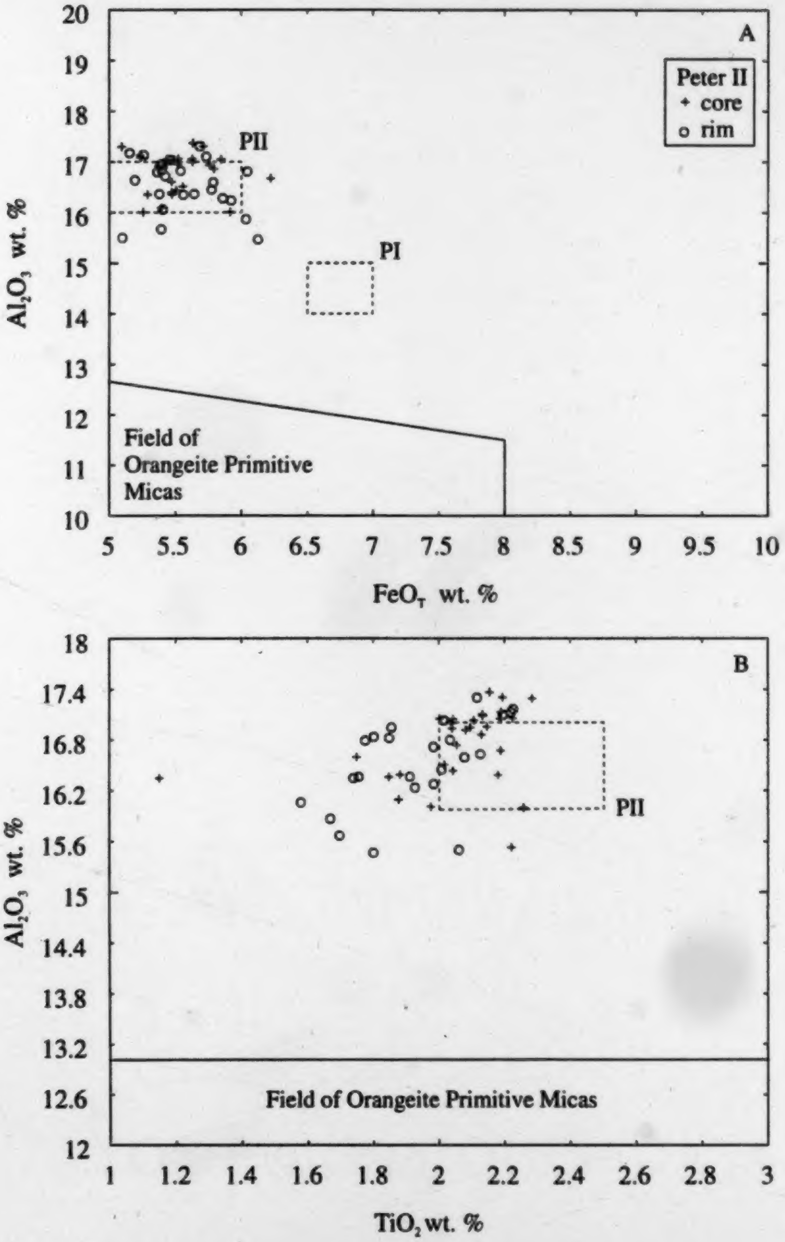


Figure 3.7. Al_2O_3 versus FeO_T (A) and TiO_2 (B) compositional variation of individual point analyses of microphenocryst cores and rims in the Peter II kimberlite. Primitive orangeite mica fields from Mitchell (1995b), and generalized boxed regions for Population I and II micas from Peter I (this work).

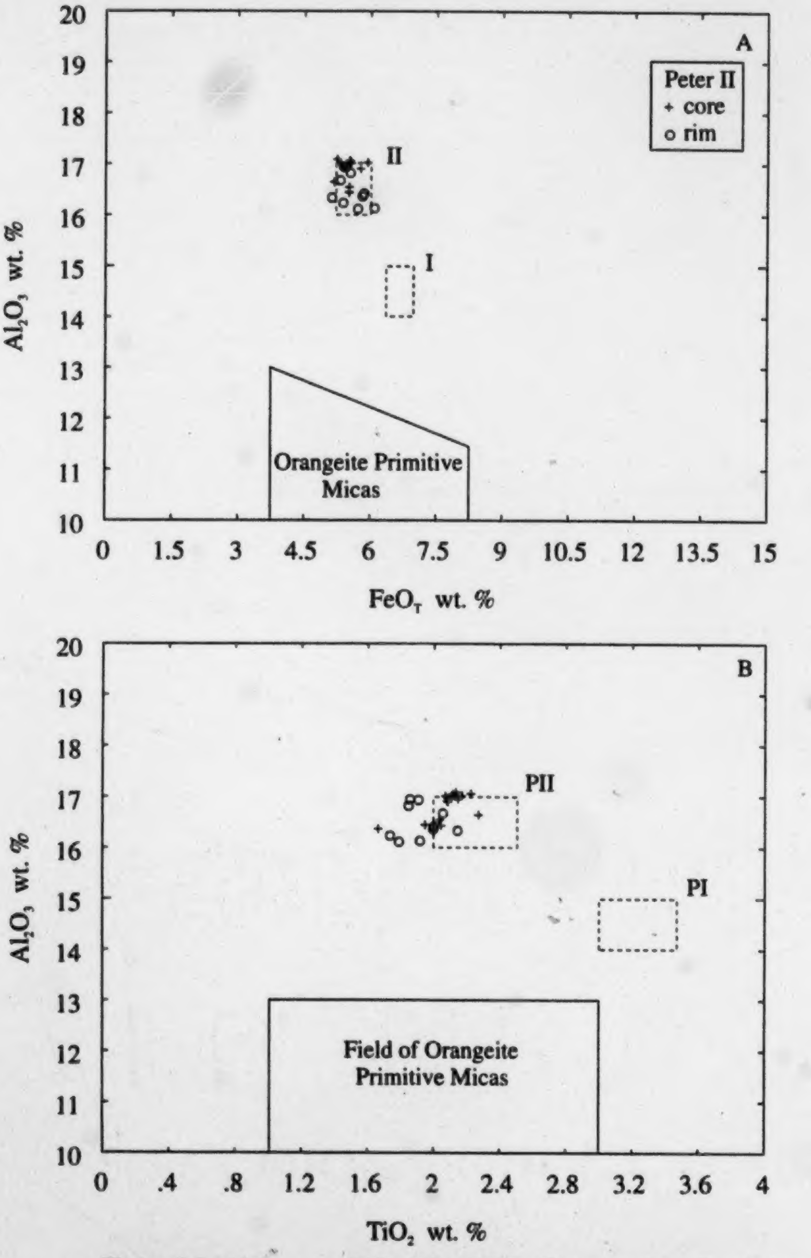


Figure 3.8. Al_2O_3 versus FeO_T (A) and TiO_2 (B) compositional variation of averaged point analyses of microphenocryst cores and rims in the Peter II kimberlite. Primitive orangeite mica fields from Mitchell (1995b), and generalized boxed regions for Population I and II micas from Peter I (this work).

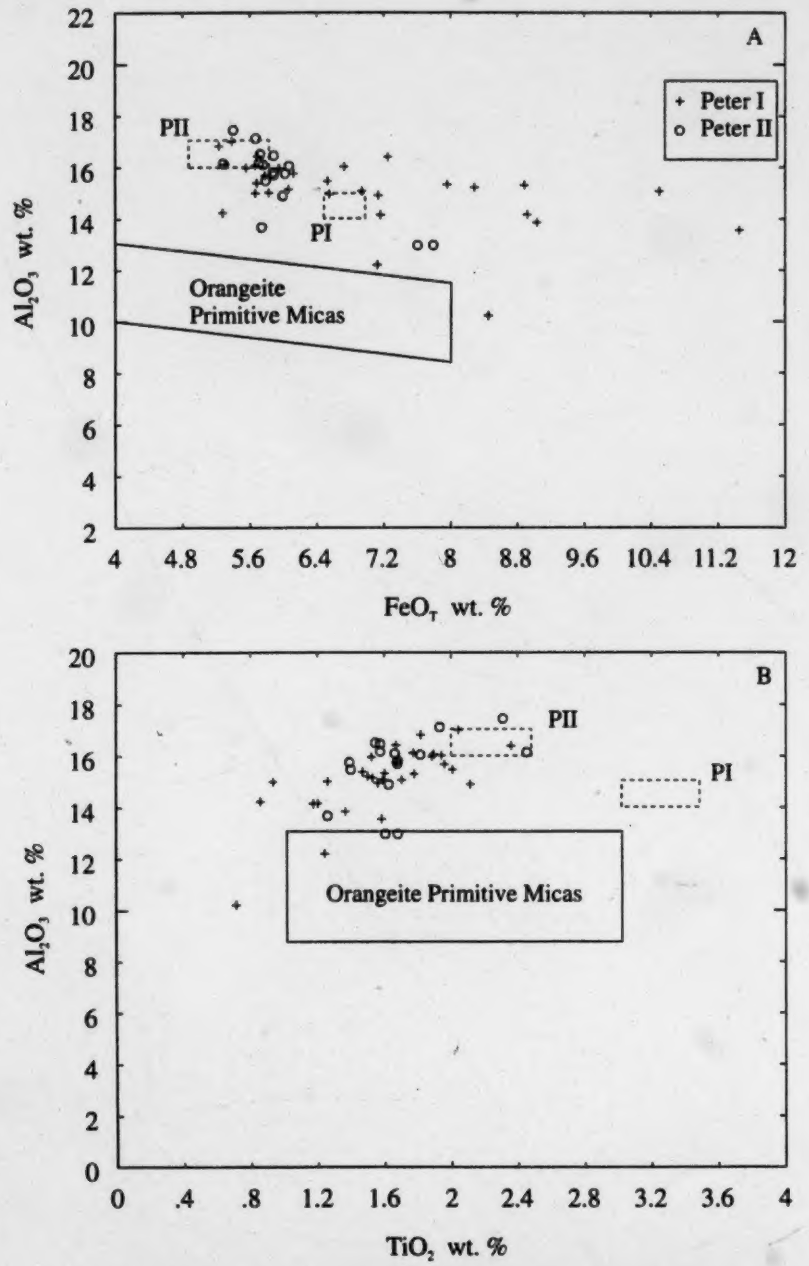


Figure 3.9. Al_2O_3 versus FeO_T (A) and TiO_2 (B) compositional variation of groundmass micas in the Peter I and Peter II kimberlites. Orangeite primitive mica fields from Mitchell (1995b), and generalized boxed regions for Population I and II micas (this work).

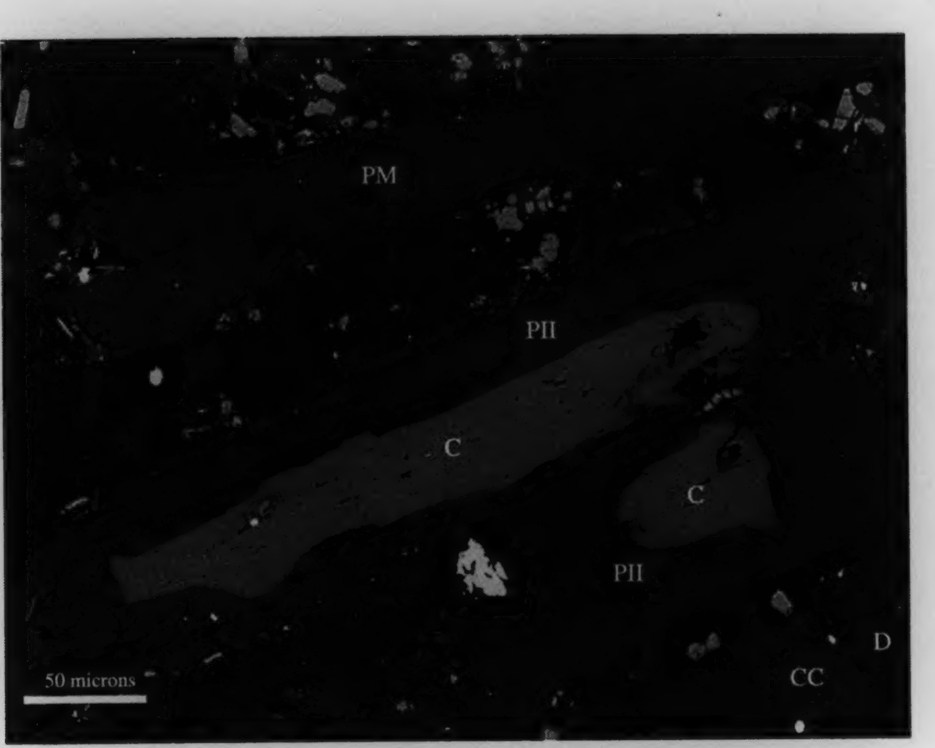
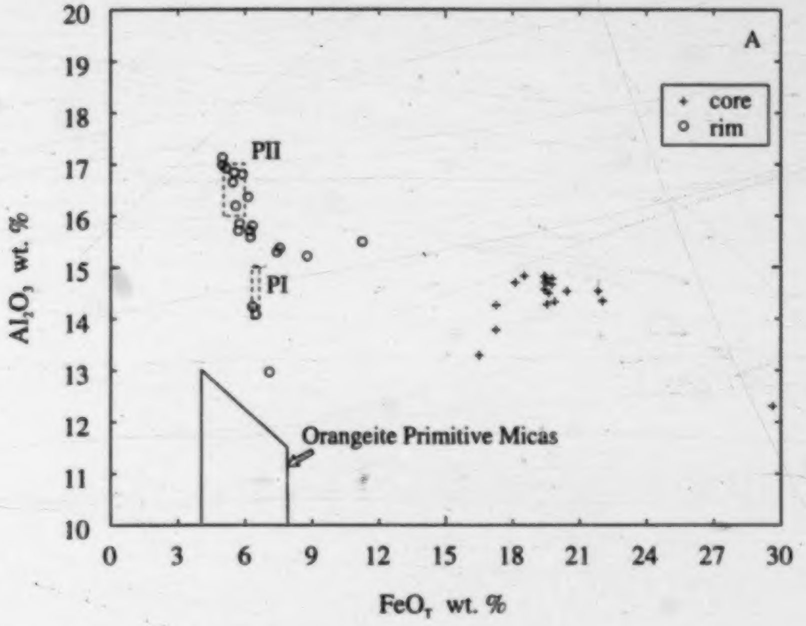


Figure 3.10. Backscattered electron image of zoned dark brown cored microphenocrysts mica from the Peter I kimberlite dyke: (C) dark brown core; (PII) Population II rim; (CC) calcite groundmass; (D) ferroan dolomite groundmass, and (PM) phlogopite microphenocryst.



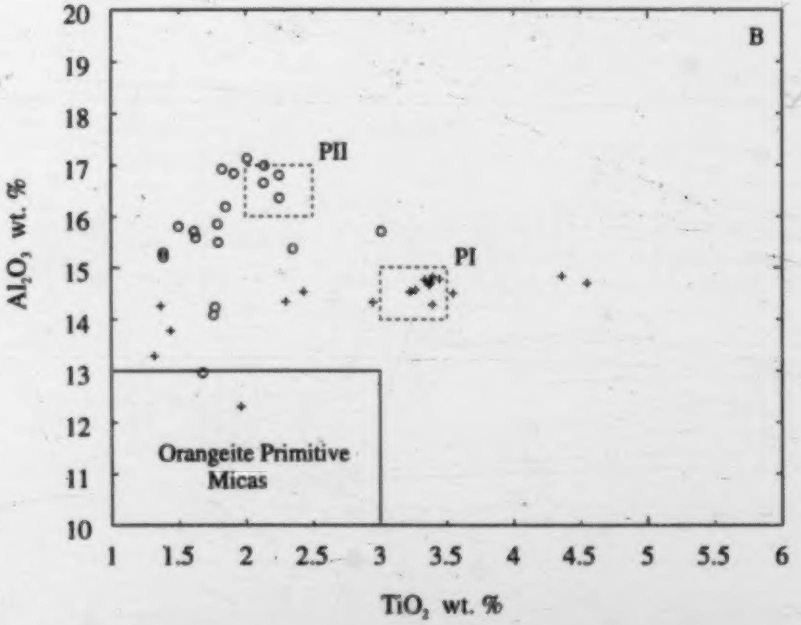


Figure 3.11. Al_2O_3 versus FeO_T (A) and TiO_2 (B) compositional variation of individual point analyses of zoned microphenocryst mica cores and rims from the Peter I kimberlite. Orangeite primitive mica fields from Mitchell (1995b), and generalized boxed regions of Population I and II micas from Peter I (this work).

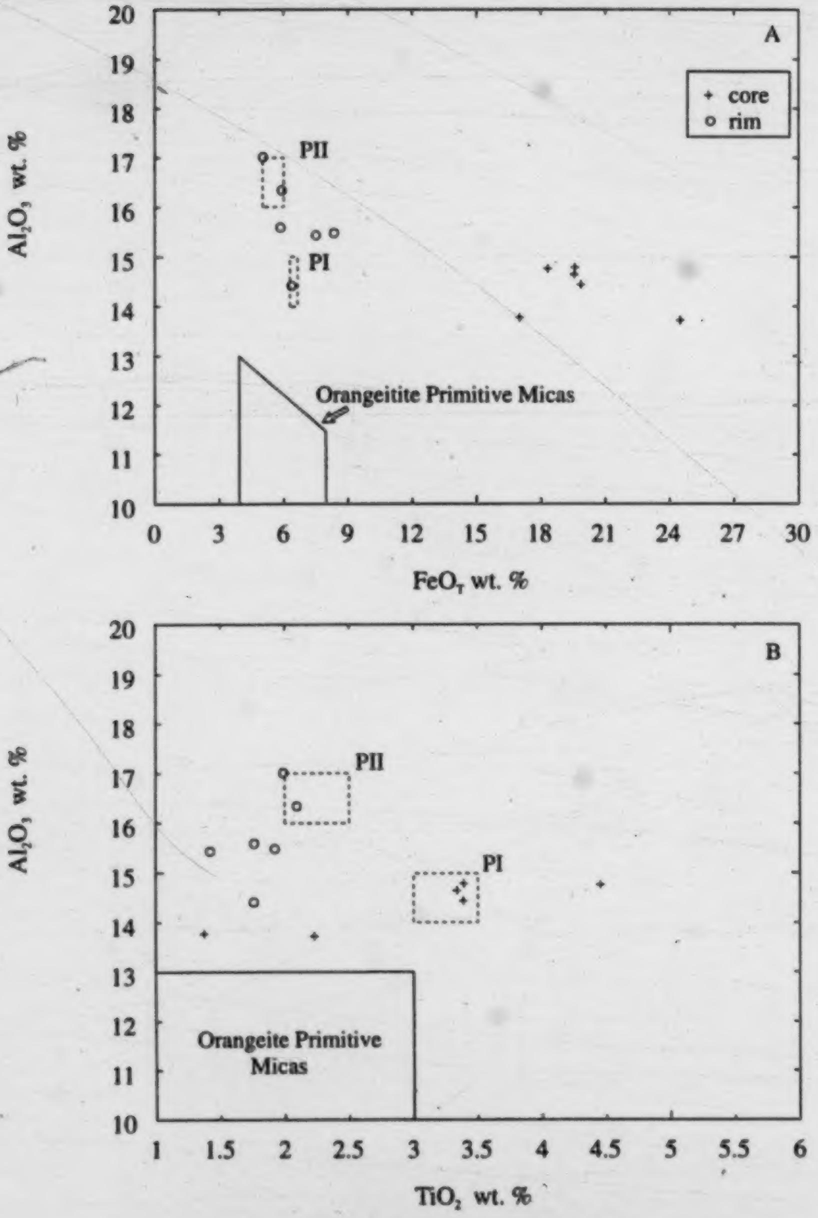


Figure 3.12. Al_2O_3 versus FeO_T (A) and TiO_2 (B) compositional variation of averaged point analysis of zoned microphenocryst mica cores and rims from the Peter I kimberlite. Orangeite primitive mica fields from Mitchell (1995b), and generalized boxed regions for Population I and II micas from Peter I (this work).

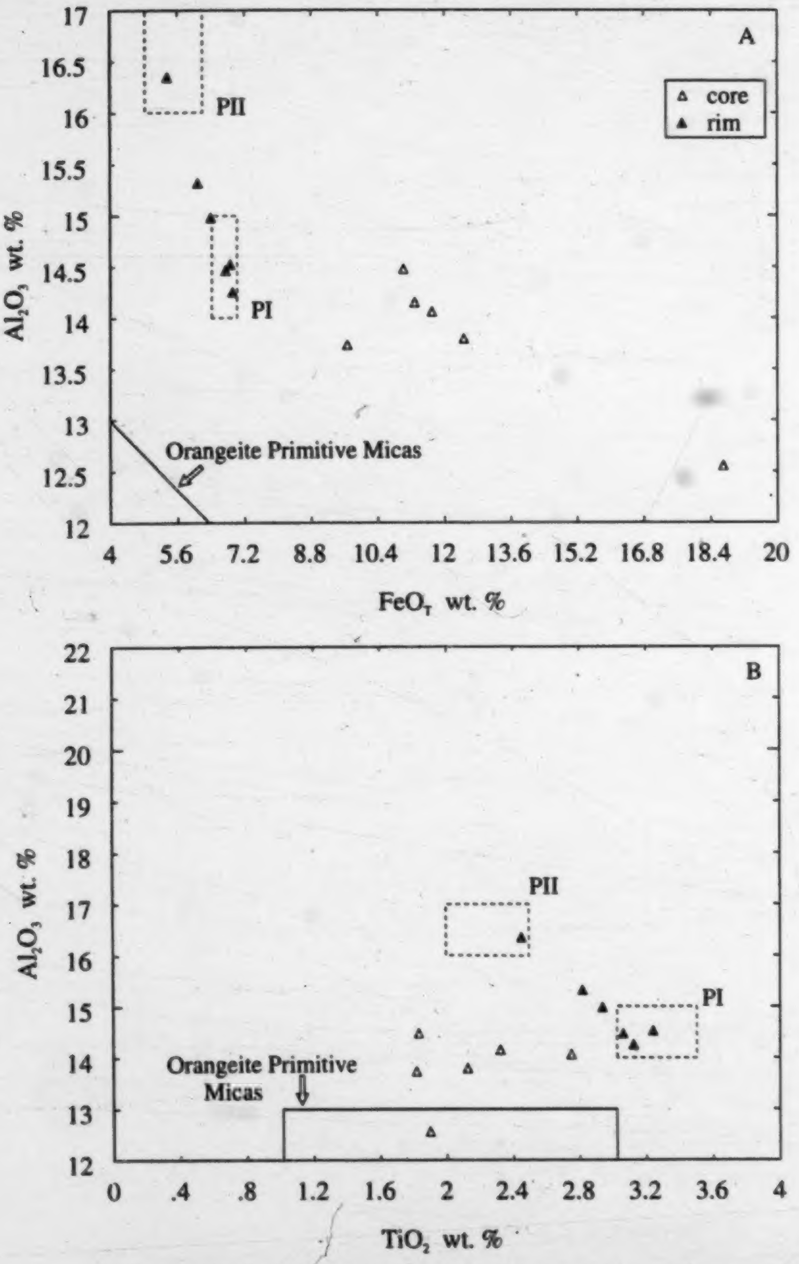


Figure 3.13. Al$_2$O$_3$ versus FeO$_T$ (A) and TiO$_2$(B) compositional variation of individual point analysis for core and rim of a single mica macrocryst/ phenocryst in the Peter I kimberlite. Orangeite primitive mica fileds from Mitchell (1995b), and generalized boxed regions for Population I and II micas from Peter I(this work).

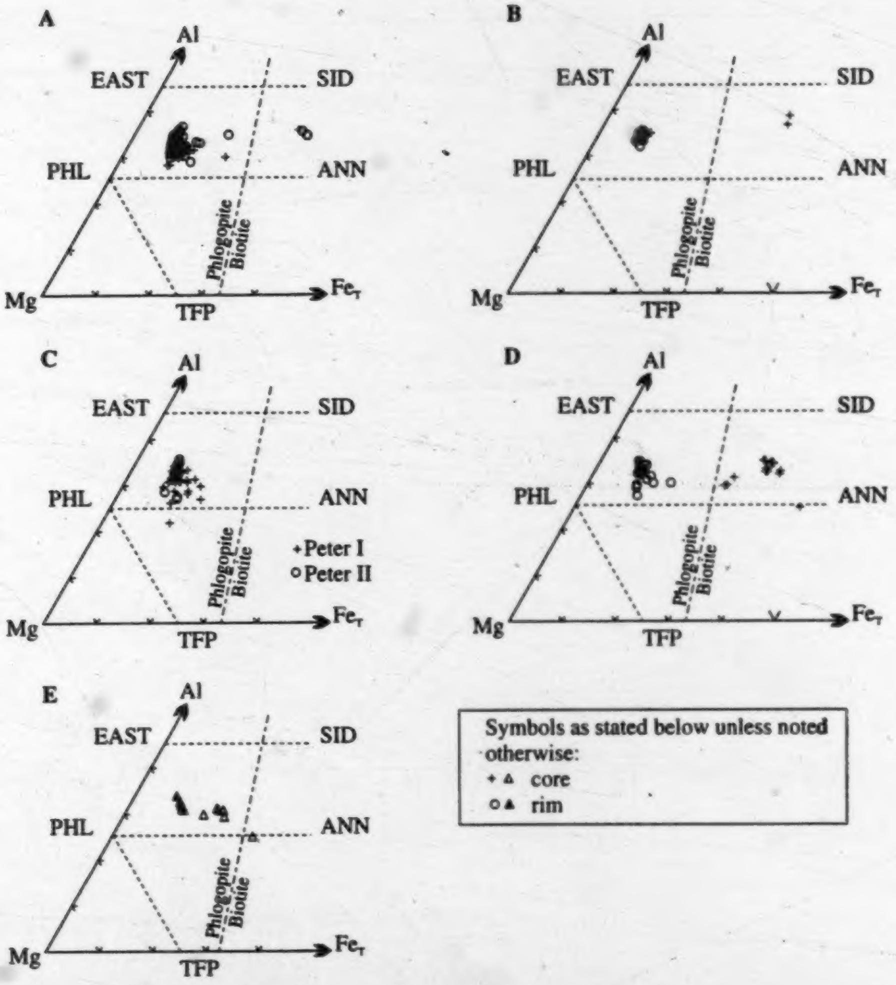


Figure 3.14. Individual compositions (atoms/11 oxygens) of microphenocryst mica from Peter I (A), Peter II (B), groundmass mica from Peter I and Peter II (C), zoned microphenocrysts from Peter I (D), and single macrocryst/phenocryst from Peter I (E), plotted in the Al-Mg-Fe_T ternary system. Fe expressed as total Fe_T. EAST= "eastonite", SID= siderophyllite, PHL= phlogopite, ANN= annite, and TFP= tetraferriphlogopite.

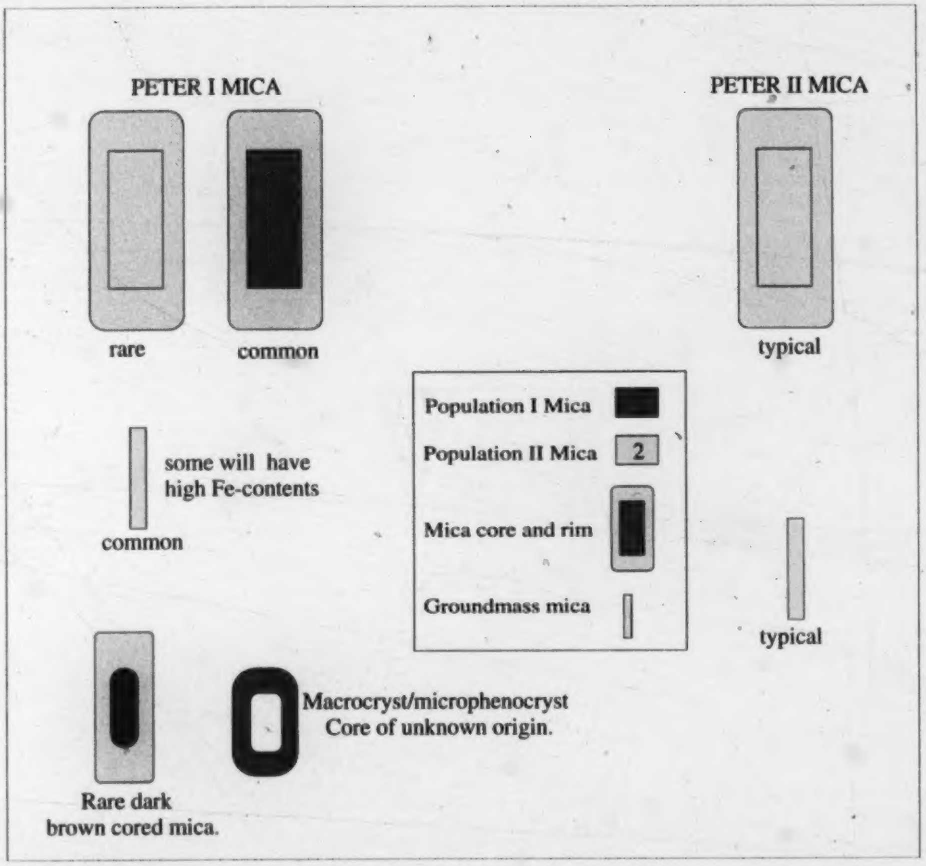

PETER I MICA
PETER II MICA
rare
common
typical
some will have high Fe-contents
common
Population I Mica
Population II Mica
2
Mica core and rim
Groundmass mica
typical
Macrocryst/microphenocryst Core of unknown origin.
Rare dark brown cored mica.

Figure 3.15. Types of mica present in the Peter I and II kimberlite dykes and their relative abundance (rare, common, and typical). Numbers 1 and 2 represent pleochroism: (1) medium pale yellow-brown; (2) colourless to pale yellow.

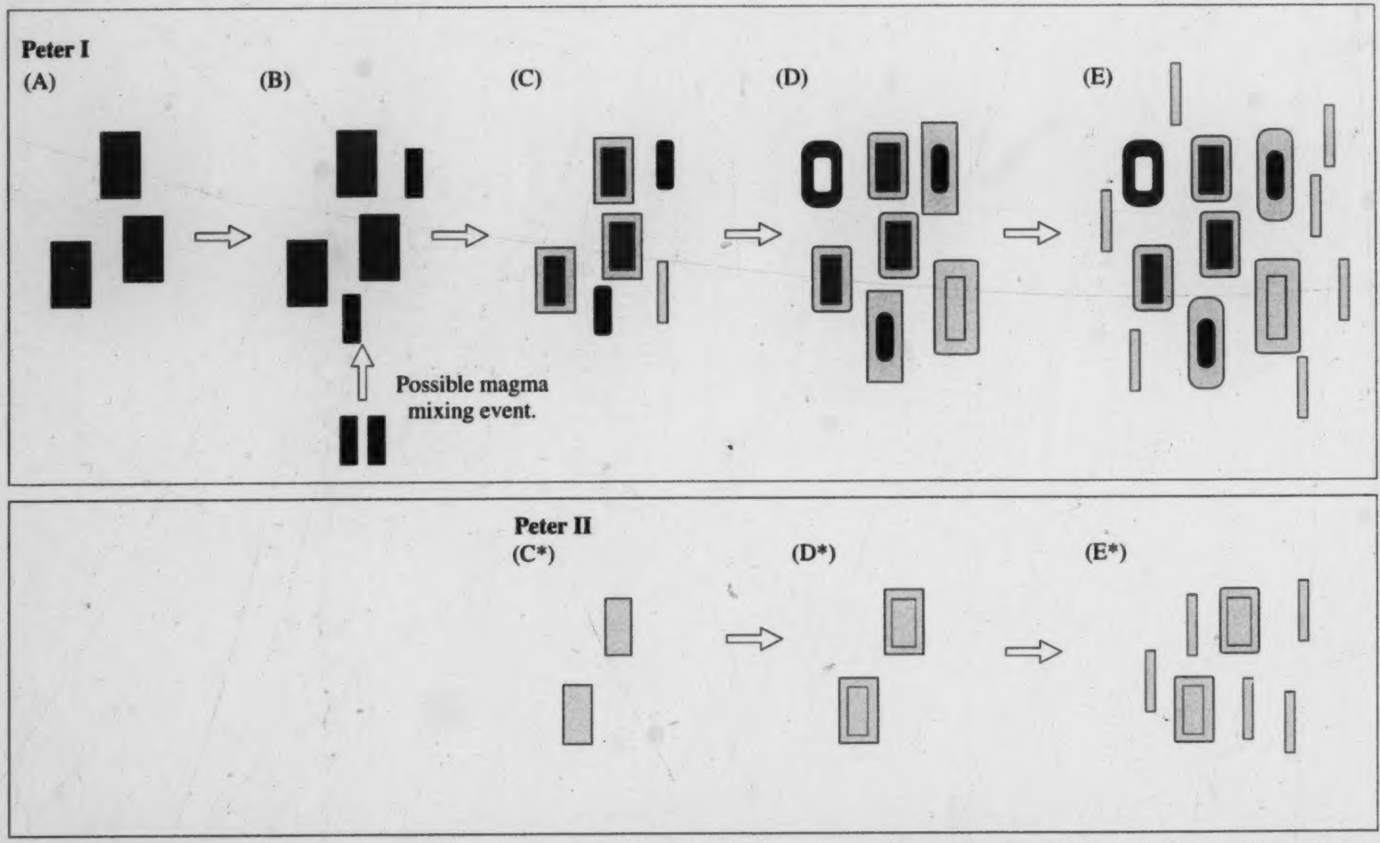


Figure 3.16. Crystallization history for mica from the Peter I and II kimberlite dykes (symbols from Fig. 3.15): (A) crystallization of PI micas ; (B) transport of micas in kimberlite magma along with a possible magma mixing event (i.e., introduction of Type I mica); (C) crystallization of PII mica begins, which is likely the result of magma mixing (see text for explanation); (C*) crystallization of PII micas begins in Peter II; (D, D*) continued crystallization of PII mica, and the introduction of the single macrocrysts/phenocryst; and (E, E*) formation of PII groundmass mica in both Peter I and II.

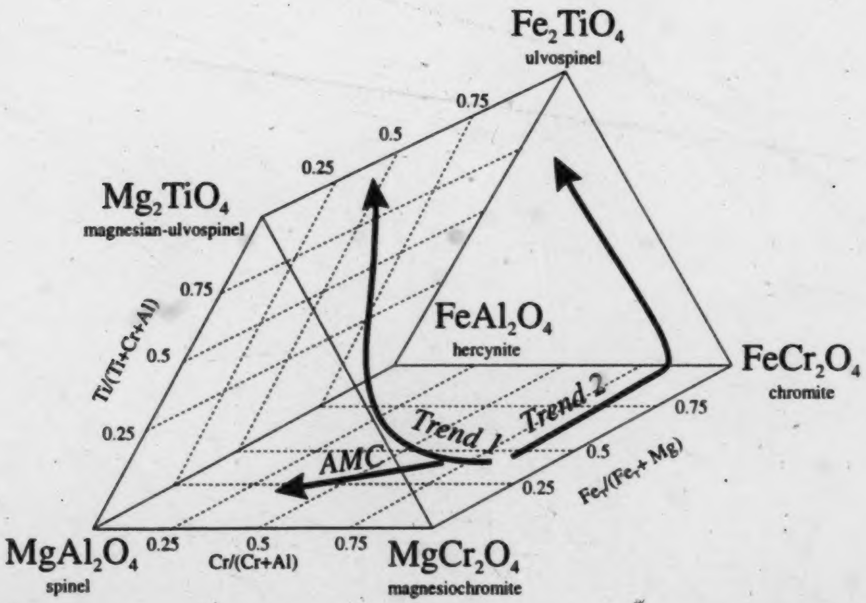

Fe_2TiO_4
ulvospinel
Mg_2TiO_4
magnesian-ulvospinel
$FeAl_2O_4$
hercynite
$FeCr_2O_4$
chromite
$MgAl_2O_4$
spinel
$MgCr_2O_4$
magnesiochromite
Ti/(Ti+Cr+Al)
Cr/(Cr+Al)
$Fe_T/(Fe_T+Mg)$
0.25
0.5
0.75
Trend 1
Trend 2
AMC

Figure 3.17. The reduced spinel prism (modified from Mitchell, 1995b) with AMC, Trend 1, and Trend 2 compositional trends plotted. Total Fe calculated as FeO (Fe_T). See text for explanation of Trend 1.

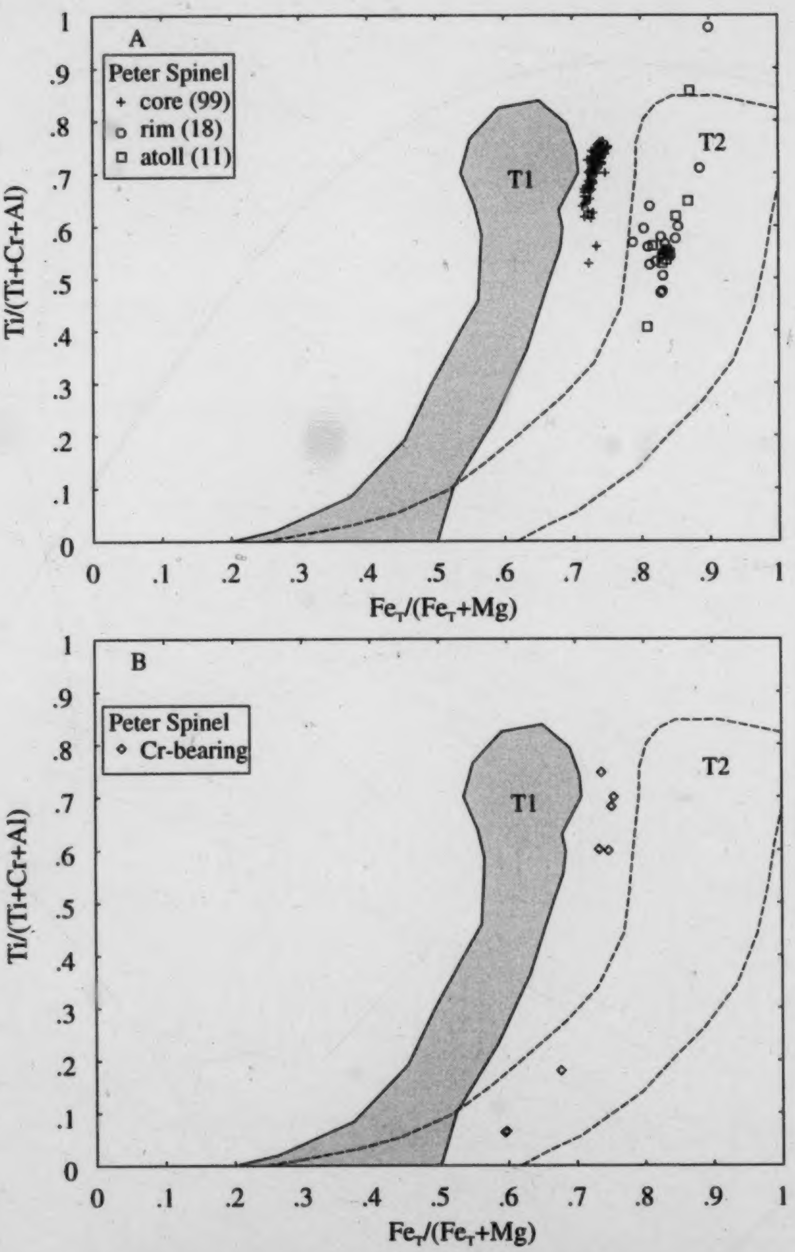


Figure 3.18. Ti/(Ti+Cr+Al) versus $Fe_T/(Fe_T+Mg)$ of individual point analyses for Peter spinel cores, rims, and atolls (A), and Cr-bearing spinels (B) relative to the generalized fields for Magmatic Trend 1 Spinels (T1) of archetypal kimberlites, and Magmatic Trend 2 Spinels (T2) modified from Mitchell (1986). Values in brackets represent number of analyses. Fe is calculated as total Fe_T.

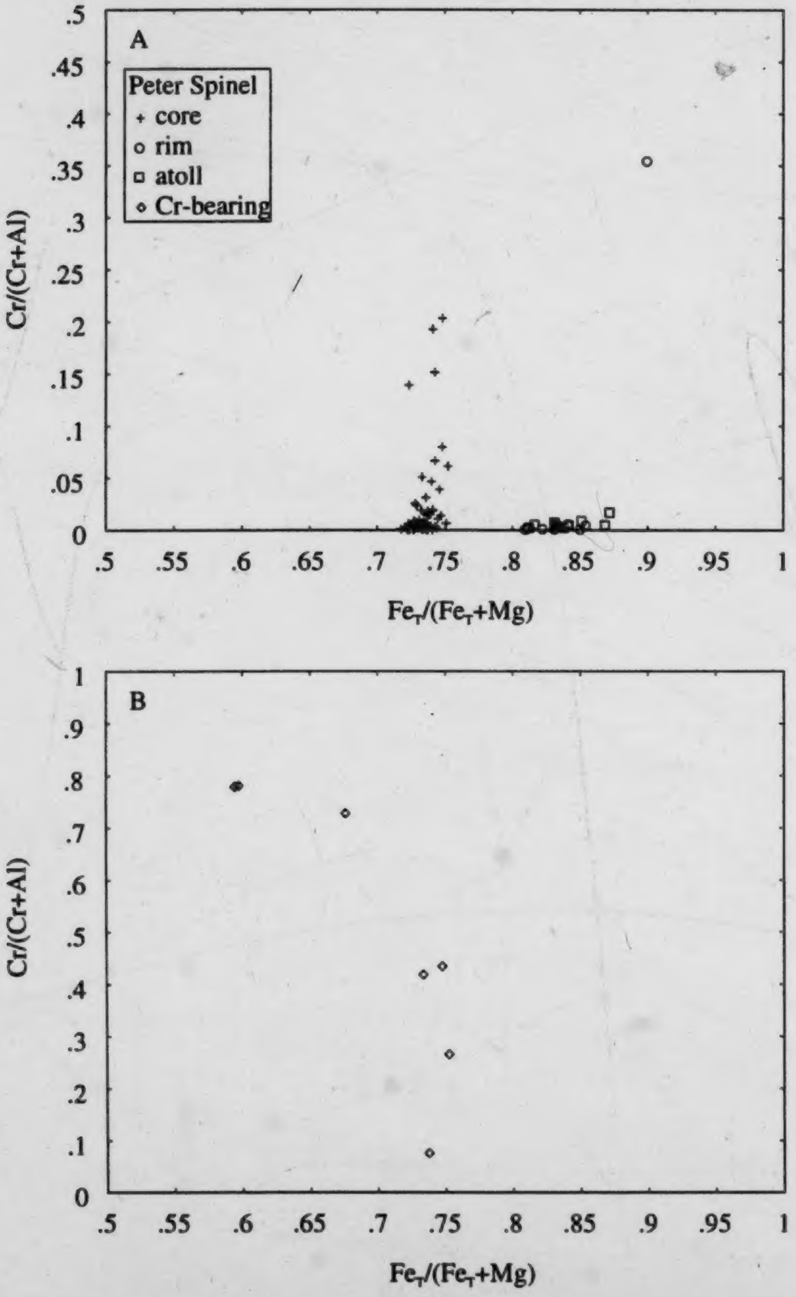


Figure 3.19. Plot of Cr/(Cr+Al) versus $Fe_T/(Fe_T+Mg)$ from the base of the reduced spinel prism for Peter spinel cores, rims, and atolls (A), and Cr-bearing spinels (B). Note scale change in A and B. Analyses with no Cr are not plotted.

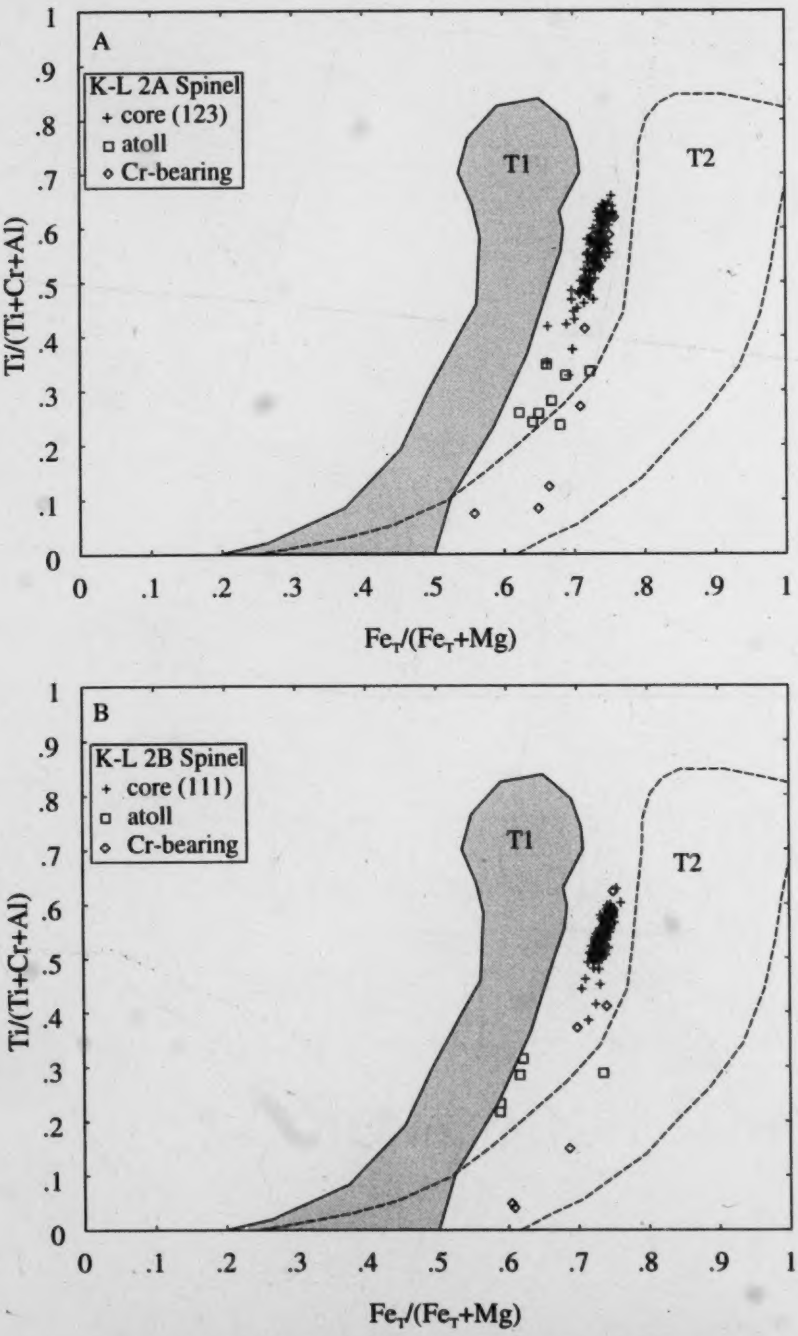


Figure 3.20. Ti/(Ti+Cr+Al) versus Fe$_T$/(Fe$_T$+Mg) of K-L 2A spinels (A),and K-L 2B spinels (B) relative to the generalized fields for Magmatic Trend 1 Spinels (T1) of archetypal kimberlites, and Magmatic Trend 2 Spinels (T2), modified from Mitchell (1986). Values in brackets represent number of analyses. Fe calculated as total Fe$_T$.

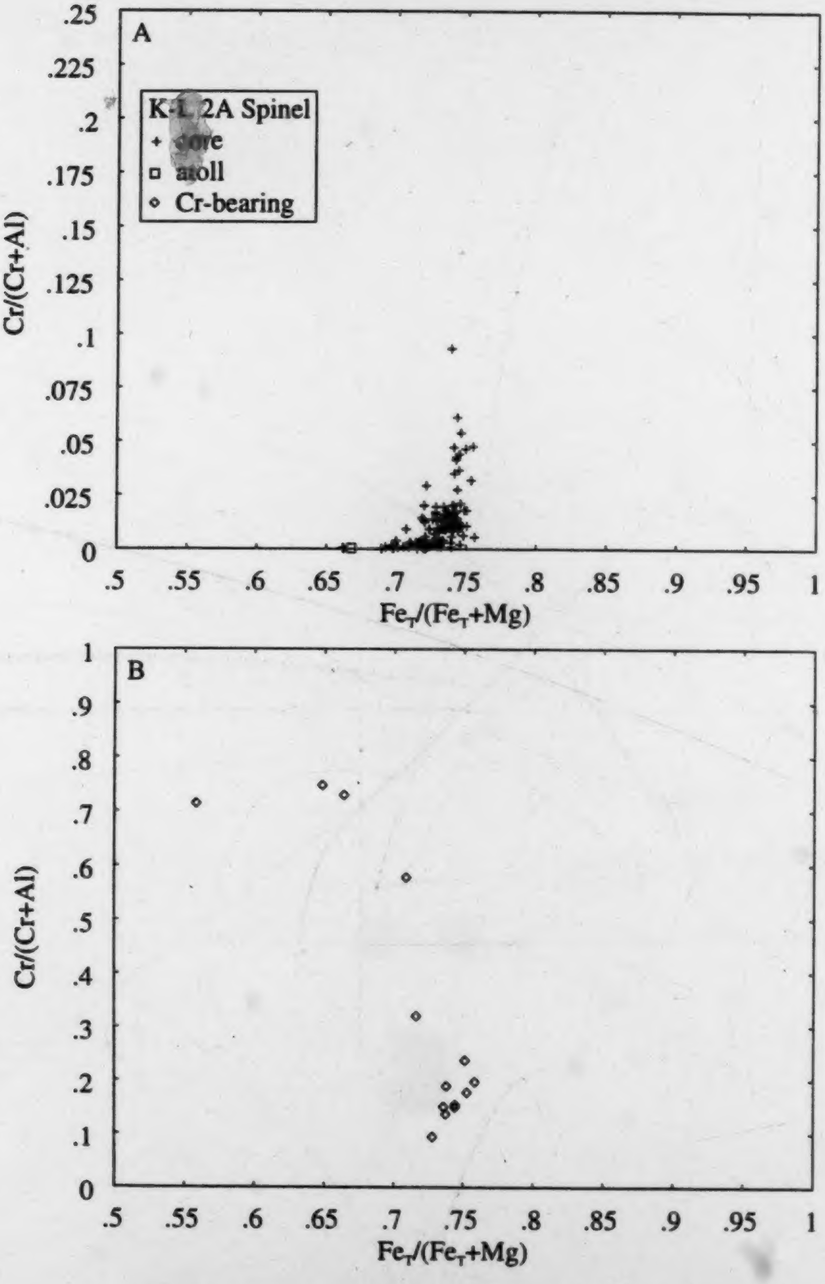


Figure 3.21. Plot of Cr/(Cr+Al) versus $Fe_T/(Fe_T+Mg)$ from the base of the reduced spinel prism for K-L 2A spinel cores, and atolls (A), and Cr-bearing spinels (B). Note scale change in A and B. Analyses with no Cr are not plotted.

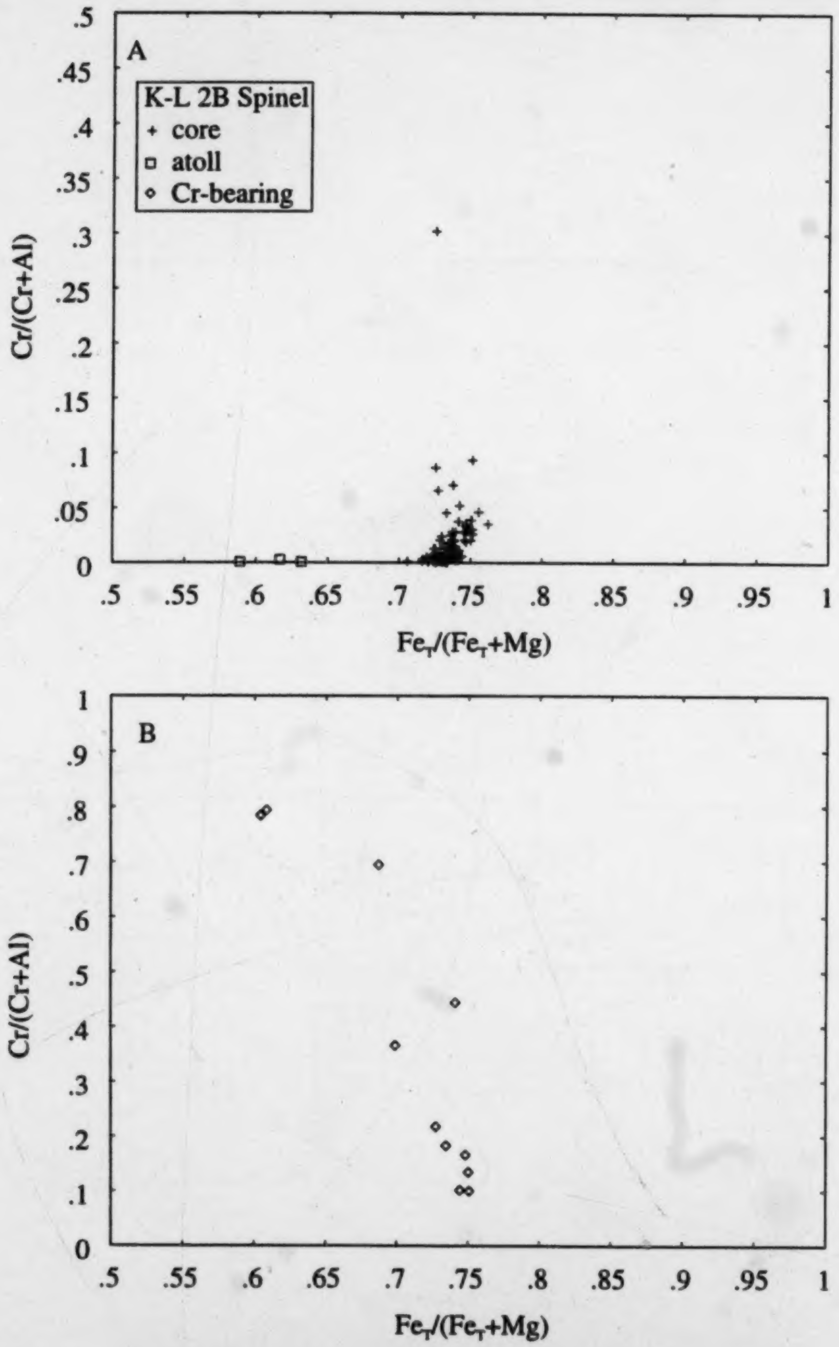


Figure 3.22. Plot of Cr/(Cr+Al) versus Fe$_T$/(Fe$_T$+Mg) from the base of the reduced spinel prism for K-L 2B spinel cores, and atolls (A), and Cr-bearing spinels (B). Note scale change in A and B. Analyses with no Cr are not plotted.

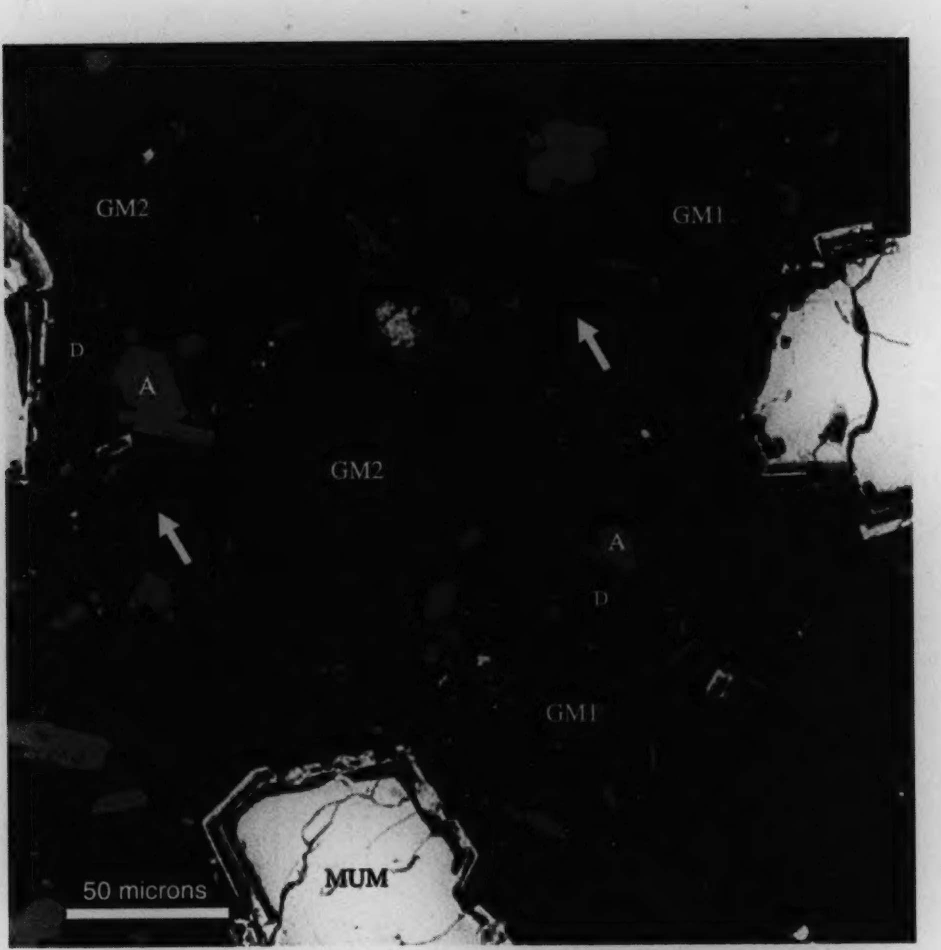

GM2
GM1
D
A
GM2
A
D
GM1
50 microns
MUM

Figure 3.23. Backscattered image of K-L 2A groundmass displaying GM2 calcite patches, GM1 material consisting of dolomite (D), apatite (A), spinel (MUM), and high Fe-bearing serpentine material (dark grey/black material pointed out by the arrows).

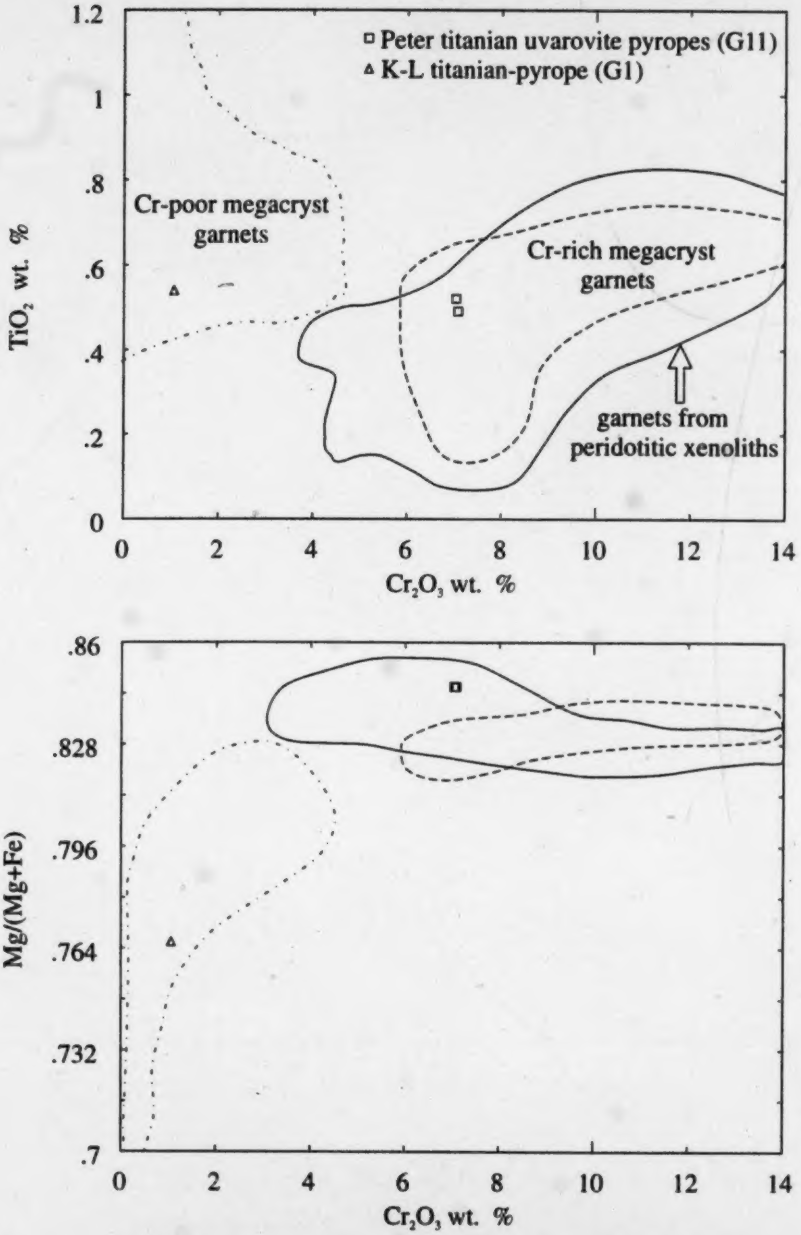


Figure 3.24. Cr_2O_3 versus TiO_2 (A) and Mg/(Mg+Fe) [B] for Cr-rich and Cr-poor garnet megacrysts, and garnets from lherzolites and harzburgites, from Colorado-Wyoming kimberlites, and Peter and K-L Ti-pyropes. Generalized fields after Eggler et al. (1979).

Table 3.1. Representative Population I and II compositions of microphenocryst micas and high Fe-bearing mica from the Peter I kimberlite.

wt. %	15C^{I}	15C^{I}	15C^{I}	15R^{II}	15R^{II}	15R^{II}	19C^{I}	19C^{I}	19R^{I}	19R^{I}
SiO_2	37.58	37.13	37.08	35.73	36.04	36.95	36.42	37.63	36.93	35.07
TiO_2	3.11	3.01	3.10	2.24	2.08	3.12	2.38	2.78	2.72	1.99
Al_2O_3	14.36	14.59	14.48	17.05	16.62	14.63	16.62	14.50	13.42	16.40
Cr_2O_3	0.11	0.07	0.12	0.00	0.00	0.13	0.00	0.14	0.03	0.01
FeO*	6.67	6.57	6.71	5.24	5.37	6.73	5.87	6.96	8.72	6.17
MnO	0.03	0.02	0.03	0.06	0.03	0.03	0.05	0.03	0.04	0.06
MgO	19.87	20.22	20.35	20.99	21.06	20.12	21.84	21.43	20.92	20.98
BaO	0.47	0.47	0.39	1.54	1.45	0.51	1.26	0.50	0.36	1.44
CaO	0.04	0.03	0.05	0.04	0.10	0.07	0.05	0.03	0.22	0.12
NiO	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.02	0.02
Na_2O	0.23	0.27	0.25	0.18	0.28	0.29	0.20	0.24	0.24	0.26
K_2O	10.50	10.30	10.51	10.11	10.19	10.53	9.97	10.31	8.96	9.48
F	0.05	0.05	0.03	0.00	0.02	0.03	0.12	0.19	0.18	0.12
Cl	0.01	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.02	0.01
Total	92.98	92.69	93.10	93.18	93.24	93.12	94.74	94.67	92.70	92.06
Strucrural formulae based on 11 oxygens										
Si	2.798	2.772	2.761	2.656	2.679	2.755	2.664	2.758	2.772	2.649
Ti	0.174	0.169	0.174	0.126	0.117	0.175	0.131	0.153	0.154	0.113
Al	1.261	1.284	1.271	1.494	1.457	1.286	1.433	1.253	1.187	1.460
Cr	0.007	0.004	0.007	0.000	0.000	0.008	0.000	0.008	0.002	0.001
Fe	0.416	0.410	0.418	0.326	0.334	0.420	0.359	0.427	0.547	0.390
Mn	0.002	0.001	0.002	0.004	0.002	0.002	0.003	0.002	0.002	0.004
Mg	2.206	2.250	2.260	2.326	2.334	2.236	2.381	2.342	2.341	2.363
Ba	0.014	0.014	0.012	0.045	0.042	0.015	0.036	0.014	0.011	0.043
Ca	0.003	0.002	0.004	0.003	0.008	0.006	0.004	0.002	0.018	0.010
Ni	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.001	0.001
Na	0.033	0.038	0.037	0.026	0.040	0.042	0.029	0.034	0.034	0.038
K	0.997	0.981	0.998	0.959	0.966	1.002	0.930	0.964	0.858	0.913
F	0.011	0.013	0.006	0.000	0.004	0.006	0.027	0.045	0.044	0.029
Cl	0.001	0.000	0.000	0.001	0.000	0.000	0.001	0.002	0.003	0.001
Total	7.921	7.938	7.949	7.965	7.983	7.951	7.997	8.004	7.973	8.013
mg	84.15	84.58	84.39	87.71	87.48	84.19	86.91	84.59	81.05	85.83

* Total Fe expressed as FeO; C = core; R = rim; mg = 100Mg/(Mg+Fe); ^{I} = Population I mica; ^{II} = Population II mica. [Fe] high Fe-bearing mica.

Table 3.1. Continued.

wt. %	13C^{II}	13C^{II}	13C^{II}	13R^{II}	13R^{II}	13R^{II}	580 C[Fe]	301 C[Fe]	164 R[Fe]	165 R[Fe]
SiO_2	36.02	36.12	36.10	36.09	37.54	36.27	36.09	36.44	36.27	36.62
TiO_2	2.31	2.10	2.27	2.15	1.43	1.78	2.48	4.12	3.24	3.39
Al_2O_3	17.15	17.17	17.28	17.16	14.64	16.85	14.06	15.61	14.92	15.02
Cr_2O_3	0.00	0.00	0.00	0.00	0.00	0.00	1.23	0.00	0.04	0.01
FeO*	5.32	5.37	5.30	5.13	6.56	5.38	12.81	18.68	19.77	19.81
MnO	0.04	0.06	0.05	0.07	0.07	0.05	0.10	0.12	0.27	0.27
MgO	22.35	22.49	22.46	22.35	22.82	22.76	18.58	11.52	11.02	11.14
BaO	1.68	1.54	1.67	1.57	0.86	1.43	0.78	0.17	0.12	0.15
CaO	0.03	0.06	0.06	0.10	0.19	0.13	0.09	0.02	0.05	0.04
NiO	0.00	0.00	0.00	0.00	0.00	0.00	0.13	0.03	0.05	0.07
Na_2O	0.17	0.17	0.15	0.19	0.19	0.18	0.54	0.31	0.24	0.29
K_2O	10.37	10.33	9.89	10.11	9.56	10.31	8.86	10.07	9.95	10.20
F	0.06	0.05	0.06	0.10	0.14	0.09	0.09	0.45	0.40	0.46
Cl	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.09	0.02	0.05
Total	95.46	95.45	95.26	94.98	93.95	95.19	95.81	97.41	96.18	97.32
Strucrural formulae based on 11 oxygens										
Si	2.622	2.627	2.625	2.633	2.762	2.643	2.693	2.738	2.775	2.773
Ti	0.127	0.115	0.124	0.118	0.079	0.097	0.139	0.233	0.186	0.193
Al	1.472	1.472	1.481	1.476	1.270	1.447	1.237	1.382	1.346	1.341
Cr	0.000	0.000	0.000	0.000	0.000	0.000	0.073	0.000	0.003	0.001
Fe	0.324	0.327	0.322	0.313	0.404	0.328	0.800	1.174	1.265	1.254
Mn	0.002	0.004	0.003	0.004	0.004	0.003	0.007	0.007	0.017	0.018
Mg	2.425	2.438	2.435	2.431	2.503	2.473	2.066	1.291	1.257	1.257
Ba	0.048	0.044	0.048	0.045	0.025	0.041	0.023	0.005	0.004	0.005
Ca	0.002	0.005	0.004	0.008	0.015	0.010	0.007	0.001	0.004	0.003
Ni	0.000	0.000	0.000	0.000	0.000	0.000	0.008	0.002	0.003	0.004
Na	0.025	0.025	0.021	0.027	0.027	0.026	0.078	0.045	0.036	0.042
K	0.963	0.959	0.918	0.941	0.897	0.959	0.844	0.965	0.972	0.985
F	0.013	0.012	0.013	0.024	0.032	0.021	0.021	0.106	0.098	0.109
Cl	0.000	0.001	0.000	0.000	0.002	0.000	0.001	0.012	0.003	0.006
Total	8.023	8.027	7.993	8.019	8.020	8.050	7.995	7.961	7.968	7.992
mg	88.22	88.19	88.32	88.60	86.11	88.29	72.10	52.37	49.83	50.06

Table 3.2. Representative compositions of microphenocryst micas from the Peter II kimberlite dyke.

wt. %	7C	7C	7C	7R	7R	7R	8C	8C	8R	8R	1[Fe]	2[Fe]
SiO_2	35.54	35.28	35.80	36.26	36.42	35.16	35.46	35.17	35.83	36.42	35.93	35.87
TiO_2	2.00	2.19	2.05	1.58	1.67	1.91	2.19	2.19	2.02	1.80	2.13	2.18
Al_2O_3	17.05	17.05	17.04	16.06	15.86	16.36	17.31	16.67	17.03	16.83	17.10	16.38
Cr_2O_3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.02
FeO*	5.85	5.63	5.44	5.41	6.04	5.38	5.71	6.23	5.46	5.40	21.19	21.74
MnO	0.05	0.09	0.06	0.06	0.06	0.03	0.09	0.06	0.06	0.08	0.12	0.12
MgO	21.89	21.89	22.07	22.13	21.70	21.28	21.93	21.79	21.84	22.31	9.57	10.15
BaO	1.61	1.78	1.66	1.29	1.32	1.34	1.88	1.69	1.56	1.49	0.25	0.26
CaO	0.16	0.18	0.30	0.37	0.27	0.13	0.05	0.08	0.05	0.04	0.00	0.08
NiO	0.04	0.02	0.03	0.01	0.04	0.01	0.04	0.02	0.00	0.00	0.11	0.11
Na_2O	0.19	0.21	0.14	0.14	0.21	0.25	0.20	0.27	0.24	0.21	0.37	0.36
K_2O	9.57	9.75	9.73	9.99	9.49	9.35	9.77	9.15	9.84	9.94	9.91	9.18
F	0.04	0.01	0.08	0.01	0.13	0.04	0.05	0.07	0.06	0.04	0.11	0.18
Cl	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.07	0.07
Total	93.97	94.07	94.37	93.30	93.17	91.23	94.66	93.35	93.96	94.54	96.84	96.61
Strucrural formulae based on 11 oxygens												
Si	2.625	2.609	2.631	2.690	2.708	2.662	2.607	2.619	2.642	2.665	2.739	2.742
Ti	0.111	0.122	0.113	0.088	0.093	0.109	0.121	0.123	0.112	0.099	0.122	0.125
Al	1.484	1.486	1.477	1.404	1.390	1.460	1.500	1.464	1.480	1.452	1.537	1.476
Cr	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.002	0.001
Fe	0.361	0.348	0.334	0.335	0.375	0.341	0.351	0.388	0.337	0.330	1.351	1.390
Mn	0.003	0.006	0.004	0.004	0.004	0.002	0.005	0.004	0.004	0.005	0.008	0.008
Mg	2.410	2.414	2.419	2.448	2.405	2.403	2.404	2.419	2.401	2.434	1.087	1.157
Ba	0.047	0.052	0.048	0.038	0.039	0.040	0.054	0.049	0.045	0.043	0.008	0.008
Ca	0.013	0.014	0.024	0.029	0.022	0.011	0.004	0.006	0.004	0.003	0.000	0.006
Ni	0.002	0.001	0.002	0.000	0.002	0.001	0.003	0.001	0.000	0.000	0.007	0.007
Na	0.028	0.031	0.021	0.020	0.031	0.036	0.029	0.038	0.035	0.030	0.055	0.053
K	0.902	0.920	0.912	0.946	0.900	0.903	0.917	0.869	0.926	0.928	0.964	0.895
F	0.010	0.002	0.019	0.003	0.031	0.009	0.011	0.016	0.013	0.010	0.027	0.044
Cl	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.009	0.009
Total	7.996	8.004	8.003	8.006	8.000	7.977	8.006	7.997	7.999	7.999	7.915	7.921
mg	86.97	87.40	87.86	87.95	86.50	87.58	87.25	86.19	87.69	88.05	44.60	45.42

* Total Fe expressed as FeO; C = core; R = rim; mg = 100Mg/(Mg+Fe); [Fe] high Fe-bearing mica.

Table 3.3. Representative compositions of groundmass micas from the Peter I and Peter II kimberlite dykes.

wt. %	28	28	30	30	36	36	41	41	35	35	35
SiO_2	36.48	36.20	35.55	36.88	36.83	36.61	36.42	36.85	39.51	37.64	37.75
TiO_2	1.82	2.05	1.60	1.67	2.12	2.01	1.56	1.18	0.72	0.86	0.94
Al_2O_3	16.82	17.00	15.32	15.76	14.90	15.46	14.95	14.14	10.21	14.22	14.99
Cr_2O_3	0.02	0.00	0.00	0.00	0.00	0.00	0.05	0.03	0.00	0.00	0.00
FeO*	5.24	5.39	7.96	6.13	7.14	6.53	6.55	7.16	8.46	5.28	5.67
MnO	0.06	0.07	0.08	0.08	0.09	0.07	0.09	0.08	0.11	0.09	0.08
MgO	22.58	22.34	22.33	22.70	22.43	22.59	23.00	23.69	24.08	23.73	23.54
BaO	1.41	1.68	1.21	1.46	1.01	1.23	1.22	1.16	0.58	1.17	1.00
CaO	0.31	0.29	0.41	0.32	0.33	0.35	0.43	0.42	0.40	0.32	0.30
NiO	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.00
Na_2O	0.12	0.12	0.14	0.14	0.15	0.16	0.14	0.11	0.09	0.12	0.10
K_2O	9.27	9.31	8.51	9.63	9.73	9.47	9.99	9.35	9.80	9.64	9.77
F	0.08	0.08	0.11	0.10	0.12	0.09	0.16	0.26	0.29	0.18	0.15
Cl	0.01	0.00	0.00	0.00	0.00	0.01	0.02	0.02	0.01	0.00	0.00
Total	94.18	94.49	93.17	94.82	94.78	94.53	94.55	94.34	94.13	93.17	94.23
Strucrural formulae based on 11 oxygens											
Si	2.667	2.647	2.659	2.698	2.705	2.688	2.689	2.723	2.933	2.785	2.762
Ti	0.100	0.113	0.090	0.092	0.117	0.111	0.087	0.065	0.040	0.048	0.052
Al	1.449	1.466	1.350	1.359	1.290	1.338	1.301	1.232	0.893	1.241	1.293
Cr	0.001	0.000	0.000	0.000	0.000	0.000	0.003	0.002	0.000	0.000	0.000
Fe	0.320	0.330	0.498	0.375	0.438	0.401	0.405	0.443	0.525	0.327	0.347
Mn	0.004	0.004	0.005	0.005	0.006	0.004	0.006	0.005	0.007	0.006	0.005
Mg	2.461	2.435	2.489	2.475	2.456	2.472	2.531	2.609	2.664	2.618	2.567
Ba	0.040	0.048	0.036	0.042	0.029	0.035	0.035	0.034	0.017	0.034	0.029
Ca	0.024	0.022	0.033	0.025	0.026	0.028	0.034	0.033	0.032	0.025	0.023
Ni	0.000	0.000	0.000	0.000	0.000	0.000	0.002	0.000	0.000	0.000	0.000
Na	0.017	0.017	0.021	0.020	0.021	0.023	0.020	0.016	0.013	0.017	0.014
K	0.865	0.869	0.812	0.899	0.912	0.887	0.941	0.882	0.928	0.910	0.912
F	0.019	0.019	0.025	0.023	0.028	0.020	0.037	0.061	0.068	0.041	0.035
Cl	0.001	0.001	0.000	0.001	0.000	0.002	0.002	0.003	0.001	0.000	0.000
Total	7.969	7.970	8.018	8.013	8.027	8.009	8.092	8.108	8.121	8.052	8.038
mg	88.48	88.08	83.33	86.85	84.85	86.04	86.22	85.50	83.53	88.90	88.09

* Total Fe expressed as FeO; mg = 100Mg/(Mg+Fe). Groundmass micas represent a lenghthwise traverse across the grain.

Table 3.3. Continued.

wt. %	385	388	394	395	411	415
SiO_2	38.05	36.94	35.24	34.86	35.38	40.50
TiO_2	1.68	1.39	1.93	2.31	1.66	1.26
Al_2O_3	12.96	15.75	17.12	17.44	16.09	13.67
Cr_2O_3	0.00	0.00	0.00	0.02	0.07	0.12
FeO*	7.61	6.02	5.68	5.41	5.76	5.75
MnO	0.06	0.07	0.08	0.04	0.06	0.08
MgO	22.70	22.88	22.02	21.84	21.90	23.74
BaO	0.66	1.12	1.76	2.11	1.39	1.04
CaO	0.32	0.58	0.39	0.28	0.18	0.47
NiO	0.00	0.03	0.00	0.00	0.01	0.03
Na_2O	0.22	0.12	0.15	0.19	0.29	0.41
K_2O	10.08	10.25	9.92	9.90	10.15	8.42
F	0.15	0.13	0.10	0.10	0.00	0.59
Cl	0.00	0.01	0.02	0.02	0.12	0.04
Total	94.42	95.23	94.36	94.48	93.03	95.85
Strucrural formulae based on 11 oxygens						
Si	2.809	2.695	2.604	2.577	2.651	2.889
Ti	0.093	0.076	0.107	0.129	0.094	0.068
Al	1.127	1.354	1.491	1.520	1.421	1.149
Cr	0.000	0.000	0.000	0.001	0.004	0.007
Fe	0.470	0.367	0.351	0.334	0.361	0.343
Mn	0.004	0.004	0.005	0.003	0.004	0.005
Mg	2.498	2.489	2.426	2.407	2.446	2.526
Ba	0.019	0.032	0.051	0.061	0.041	0.029
Ca	0.025	0.045	0.031	0.022	0.014	0.036
Ni	0.000	0.002	0.000	0.000	0.001	0.001
Na	0.031	0.017	0.022	0.028	0.042	0.057
K	0.949	0.954	0.935	0.934	0.971	0.767
F	0.035	0.029	0.024	0.023	0.000	0.132
Cl	0.000	0.001	0.003	0.003	0.016	0.005
Total	8.060	8.066	8.048	8.041	8.065	8.014
mg	84.17	87.14	87.37	87.80	87.14	88.05

Table 3.4. Representative compositions of dark brown cored microphenocryst mica from the Peter I kimberlite dyke.

wt. %	1C	1C	1C	1R	1R	1R	2C	2C	2C	2R	2R	2R
SiO_2	36.49	36.35	35.86	37.01	33.98	36.28	37.84	37.66	37.22	35.95	36.07	36.03
TiO_2	3.55	3.40	3.23	1.63	1.80	2.35	1.44	1.32	1.37	1.83	2.01	2.14
Al_2O_3	14.50	14.28	14.53	15.58	15.49	15.37	13.78	13.29	14.26	16.92	17.12	16.99
Cr_2O_3	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FeO*	19.62	19.56	20.45	6.24	11.26	7.55	17.27	16.51	17.28	5.16	5.01	5.00
MnO	0.23	0.24	0.26	0.07	0.06	0.07	0.17	0.18	0.16	0.05	0.02	0.04
MgO	11.95	11.68	12.28	22.86	22.00	21.93	16.12	15.81	15.04	22.39	22.50	22.25
BaO	0.12	0.06	0.07	0.90	0.91	0.88	0.19	0.11	0.13	1.28	1.36	1.43
CaO	0.06	0.11	0.06	0.12	0.07	0.11	0.03	0.02	0.11	0.09	0.06	0.12
NiO	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00
Na_2O	0.26	0.27	0.25	0.19	0.21	0.26	1.00	0.90	0.89	0.15	0.23	0.21
K_2O	9.60	9.74	8.97	10.04	7.64	9.51	9.08	9.21	9.12	9.86	9.90	9.95
F	0.30	0.30	0.32	0.09	0.14	0.08	0.36	0.32	0.29	0.04	0.04	0.04
Cl	0.08	0.08	0.07	0.00	0.01	0.00	0.01	0.01	0.01	0.00	0.00	0.00
Total	96.62	95.92	96.21	94.70	93.50	94.35	97.14	95.20	95.78	93.70	94.30	94.18
Strucrural formulae based on 11 oxygens												
Si	2.771	2.784	2.740	2.706	2.564	2.676	2.818	2.854	2.812	2.648	2.640	2.643
Ti	0.203	0.196	0.186	0.090	0.102	0.131	0.081	0.075	0.078	0.101	0.111	0.118
Al	1.298	1.289	1.308	1.343	1.377	1.336	1.210	1.187	1.270	1.469	1.477	1.469
Cr	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Fe	1.246	1.253	1.307	0.382	0.711	0.466	1.076	1.046	1.092	0.318	0.306	0.307
Mn	0.015	0.016	0.017	0.004	0.004	0.005	0.010	0.012	0.010	0.003	0.001	0.002
Mg	1.353	1.334	1.399	2.491	2.474	2.412	1.789	1.786	1.694	2.459	2.454	2.433
Ba	0.004	0.002	0.002	0.026	0.027	0.025	0.006	0.003	0.004	0.037	0.039	0.041
Ca	0.005	0.009	0.005	0.010	0.006	0.009	0.003	0.002	0.009	0.007	0.005	0.009
Ni	0.000	0.000	0.002	0.000	0.000	0.000	0.000	0.000	0.002	0.000	0.000	0.000
Na	0.039	0.041	0.037	0.027	0.031	0.037	0.145	0.132	0.130	0.021	0.033	0.030
K	0.930	0.952	0.874	0.937	0.735	0.895	0.863	0.891	0.879	0.927	0.924	0.931
F	0.073	0.072	0.077	0.022	0.034	0.018	0.085	0.077	0.070	0.009	0.009	0.010
Cl	0.010	0.011	0.009	0.000	0.001	0.000	0.002	0.001	0.001	0.000	0.000	0.000
Total	7.945	7.955	7.962	8.036	8.064	8.009	8.086	8.067	8.050	7.999	7.999	7.995
mg	52.06	51.57	51.70	86.71	77.69	83.80	62.45	63.06	60.80	88.55	88.90	88.80

* Total Fe expressed as FeO; C = core; R = rim; mg = 100Mg/(Mg+Fe).

Table 3.5. Individual point analysis of the core and rim from the single mica macrocryst/phenocryst from the Peter I kimberlite dyke.

wt. %	C	C	C	C	C	R	R	R	R	R
SiO_2	31.76	37.95	36.96	37.15	37.57	37.12	37.26	36.57	37.73	35.99
TiO_2	1.90	1.82	2.33	2.75	1.83	2.82	3.24	3.13	3.06	2.45
Al_2O_3	12.55	13.73	14.15	14.06	14.47	15.32	14.52	14.25	14.46	16.35
Cr_2O_3	0.43	0.69	0.50	0.27	0.33	0.06	0.14	0.18	0.12	0.04
FeO*	18.70	9.67	11.29	11.71	11.02	6.09	6.87	6.92	6.75	5.37
MnO	0.10	0.08	0.09	0.12	0.09	0.05	0.07	0.05	0.06	0.07
MgO	19.19	20.10	18.84	18.45	19.12	21.68	21.56	21.35	21.59	22.20
BaO	0.42	0.61	1.08	1.18	0.56	0.63	0.46	0.57	0.42	1.29
CaO	0.19	0.00	0.00	0.03	0.00	0.01	0.02	0.02	0.01	0.04
NiO	0.11	0.16	0.15	0.12	0.08	0.02	0.08	0.05	0.08	0.00
Na_2O	0.32	0.58	0.55	0.57	0.44	0.20	0.20	0.23	0.26	0.21
K_2O	5.27	9.79	9.57	9.53	10.02	10.30	10.43	10.25	10.28	10.08
F	0.20	0.20	0.17	0.21	0.23	0.18	0.13	0.15	0.15	0.12
Cl	0.01	0.00	0.01	0.01	0.03	0.01	0.02	0.02	0.03	0.01
Total	91.07	95.30	95.61	96.06	95.69	94.41	94.94	93.66	94.93	94.16
Strucrural formulae based on 11 oxygens										
Si	2.540	2.801	2.751	2.757	2.778	2.720	2.727	2.719	2.754	2.649
Ti	0.114	0.101	0.130	0.154	0.102	0.155	0.178	0.175	0.168	0.136
Al	1.183	1.195	1.241	1.230	1.261	1.323	1.253	1.249	1.244	1.418
Cr	0.027	0.040	0.029	0.016	0.019	0.004	0.008	0.011	0.007	0.003
Fe	1.251	0.597	0.703	0.727	0.681	0.373	0.420	0.430	0.412	0.331
Mn	0.007	0.005	0.006	0.007	0.006	0.003	0.004	0.003	0.004	0.004
Mg	2.288	2.212	2.091	2.041	2.108	2.368	2.352	2.366	2.349	2.436
Ba	0.013	0.018	0.031	0.034	0.016	0.018	0.013	0.017	0.012	0.037
Ca	0.016	0.000	0.000	0.003	0.000	0.000	0.001	0.001	0.001	0.003
Ni	0.007	0.010	0.009	0.007	0.005	0.001	0.005	0.003	0.005	0.000
Na	0.049	0.083	0.080	0.082	0.063	0.029	0.029	0.034	0.037	0.030
K	0.537	0.922	0.909	0.902	0.945	0.963	0.974	0.973	0.957	0.946
F	0.050	0.047	0.041	0.050	0.053	0.041	0.030	0.034	0.034	0.029
Cl	0.001	0.000	0.001	0.001	0.004	0.002	0.002	0.002	0.004	0.001
Total	8.084	8.030	8.021	8.010	8.041	8.000	7.998	8.016	7.987	8.023
mg	64.65	78.74	74.84	73.74	75.57	86.38	84.84	84.62	85.07	88.05

* Total Fe expressed as FeO; C = core; R = rim; mg = 100Mg/(Mg+Fe).

Table 3.6. Representative spinel compositions from Peter.

wt. %	Peter C MUM	Peter C MUM	Ti-mt R	374 R	Ti-mt A	Ti-mt A	TIMAC	Cr-bearing MUM
n	71	28	18	1	11	1	1	1
TiO_2	18.55	18.29	7.73	10.90	6.95	9.42	4.27	17.29
Al_2O_3	4.87	4.84	3.79	4.74	3.59	4.66	8.55	4.25
Cr_2O_3	0.12	0.09	0.01	0.00	0.02	0.04	45.56	4.57
FeO_T	59.03	59.23	72.19	68.23	72.83	69.90	28.59	57.33
MnO	0.68	0.67	1.01	0.87	1.17	0.90	0.36	0.63
MgO	12.13	11.97	8.05	9.38	7.92	8.80	10.81	11.68
Nb_2O_5	0.03	0.05	0.05	0.03	0.07	0.01	0.00	0.00
Total	95.41	95.14	92.83	94.15	92.55	93.73	98.14	95.75
Recalculated Analysis based on Droop (1987)								
FeO	29.41	29.36	24.93	26.34	24.19	25.74	19.93	28.97
Fe_2O_3	32.92	33.19	52.52	46.55	54.05	49.07	9.62	31.51
Total	98.71	98.46	98.09	98.81	97.96	98.64	99.10	98.91
$Fe_T/(Fe_T+Mg)$	0.732	0.735	0.834	0.803	0.838	0.817	0.597	0.734
Ti/(Ti+Cr+Al)	0.705	0.704	0.565	0.595	0.552	0.562	0.065	0.601
Cr/(Cr+Al)	0.016	0.012	0.002	0.000	0.004	0.006	0.781	0.419
Mol. % Endmember Compositions								
$MgAl_2O_4$	9.80	9.90	8.00	-	9.80	9.70	17.00	8.60
Mg_2TiO_4	26.00	25.60	17.50	-	19.50	18.30	10.90	25.60
Mn_2TiO_4	1.00	1.00	1.60	-	1.30	1.40	15.50	0.90
Fe_2TiO_4	21.00	20.10	1.70	-	8.00	5.30	0.50	18.10
$MgCr_2O_4$	-	-	-	-	-	-	-	-
$MnCr_2O_4$	-	-	-	-	-	-	-	-
$FeCr_2O_4$	0.20	0.20	-	-	-	0.10	44.70	6.20
Fe_3O_4	42.30	43.20	71.30	-	61.40	65.20	11.50	40.70

FeO_T = total Fe expressed as FeO; n = number of analyses; C = core; R = rim; A = atoll.

Ti-mt= Ti-bearing magnetite.

Table 3.7. Representative compositions of spinels from K-L 2A.

wt. %	C MUM	A	97 C MUM	97 A	120C MUM	120 A	31 TIMAC	150 TIMAC
n	123	7	1	1	1	1	1	1
TiO_2	16.27	6.55	16.25	5.96	13.81	5.65	5.02	11.06
Al_2O_3	8.62	10.74	8.93	10.87	11.63	11.59	8.78	8.04
Cr_2O_3	0.13	0.01	0.24	0.00	0.02	0.02	38.69	16.36
FeO_T	58.17	57.43	58.51	54.11	55.67	59.69	32.89	48.22
MnO	0.57	1.07	0.45	1.01	0.63	1.05	0.41	0.56
MgO	12.15	16.08	11.79	18.47	13.31	15.74	10.00	11.12
Nb_2O_5	0.02	0.14	0.03	0.11	0.00	0.13	0.00	0.00
Total	95.93	92.02	96.20	90.53	95.07	93.87	95.79	95.36
Recalculated Analysis based on Droop (1987)								
FeO	28.19	12.39	28.98	7.79	24.34	12.87	21.14	24.68
Fe_2O_3	33.31	50.05	32.81	51.47	34.81	52.03	13.06	26.17
Total	99.27	97.03	99.49	95.68	98.56	99.08	97.10	97.98
$Fe_T/(Fe_T+Mg)$	0.729	0.667	0.736	0.622	0.701	0.680	0.648	0.709
Ti/(Ti+Cr+Al)	0.544	0.280	0.533	0.259	0.431	0.237	0.084	0.271
Cr/(Cr+Al)	0.010	0.001	0.018	0.000	0.001	0.001	0.747	0.577
Mol. % End member Compositions								
$MgAl_2O_4$	17.00	-	17.50	-	22.60	-	-	16.20
Mg_2TiO_4	21.80	-	20.50	-	21.40	-	-	20.10
Mn_2TiO_4	0.80	-	0.70	-	0.90	-	-	0.80
Fe_2TiO_4	18.30	-	19.40	-	11.90	-	-	7.40
$MgCr_2O_4$	-	-	-	-	-	-	-	-
$MnCr_2O_4$	-	-	-	-	-	-	-	-
$FeCr_2O_4$	0.20	-	0.30	-	0.10	-	-	22.10
Fe_3O_4	42.00	-	41.50	-	43.20	-	-	33.40

FeO_T = total Fe expressed as FeO; C = core; A = atoll; n= number of analyses.

Table 3.8. Representative compositions of spinels from K-L 2B.

wt. %	C MUM	A	49 C MUM	49 A	11 C MUM	11A	236 TIMAC	199 TIMAC
n	111	5						
TiO_2	15.85	8.42	14.31	8.15	15.34	7.98	2.73	3.2
Al_2O_3	8.66	14.98	10.67	17.11	9.20	18.38	8.31	8.62
Cr_2O_3	0.16	0.02	0.00	0.00	0.06	0.02	47.55	46.47
FeO_T	58.78	51.71	57.66	48.22	59.26	45.30	27.38	28.16
MnO	0.55	0.83	0.57	0.82	0.65	0.80	0.37	0.33
MgO	11.95	16.99	13.15	18.80	12.07	17.74	9.88	10.34
Nb_2O_5	0.02	0.06	0.00	0.01	0.05	0.15	0.03	0.05
Total	95.97	93.01	96.36	93.11	96.63	90.37	96.25	97.17
Recalculated Analysis based on Droop (1987)								
FeO	28.17	13.70	25.38	11.00	27.77	11.88	19.34	19.47
Fe_2O_3	34.02	42.24	35.87	41.36	35.00	37.15	8.94	9.66
Total	99.38	97.24	99.95	97.25	100.13	94.09	97.15	98.14
$Fe_T/(Fe_T+Mg)$	0.734	0.631	0.711	0.590	0.734	0.589	0.609	0.604
Ti/(Ti+Cr+Al)	0.536	0.264	0.461	0.233	0.514	0.217	0.042	0.049
Cr/(Cr+Al)	0.012	0.001	0.000	0.000	0.004	0.001	0.793	0.783
Mol. % End member Compositions								
$MgAl_2O_4$	17.00	-	20.60	-	18.00	-	16.70	17.2
Mg_2TiO_4	21.30	-	21.80	-	20.80	-	7.00	8.2
Mn_2TiO_4	0.80	-	0.80	-	0.90	-	-	-
Fe_2TiO_4	17.70	-	12.60	-	16.50	-	-	-
$MgCr_2O_4$	-	-	-	-	-	-	19.80	18.6
$MnCr_2O_4$	-	-	-	-	-	-	1.10	0.9
$FeCr_2O_4$	0.30	-	-	-	0.10	-	43.60	42.8
Fe_3O_4	43.00	-	44.30	-	43.80	-	11.80	12.4

FeO_T = total Fe expressed as FeO; C = core; A = atoll; n= number of analyses.

Table 3.9. Representative compositions of K-L 2B apatites.

wt. %	67	79	84	99	109	124	128	134
SiO_2	4.50	4.53	3.69	2.95	2.65	3.07	3.74	3.94
FeO*	0.64	0.47	0.26	0.11	0.08	0.30	0.44	0.14
MnO	0.03	0.03	0.05	0.03	0.00	0.00	0.04	0.04
MgO	0.90	0.92	0.32	0.21	0.16	0.21	0.81	0.28
CaO	51.98	52.51	53.86	54.57	53.87	54.29	53.91	53.92
SrO	0.46	0.44	0.44	0.48	0.52	0.54	0.49	0.64
UO_2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
P_2O_5	32.26	32.41	32.10	34.61	34.80	33.81	33.39	31.01
La_2O_3	0.16	0.12	0.23	0.17	0.23	0.34	0.23	0.07
Ce_2O_3	0.21	0.27	0.22	0.27	0.27	0.35	0.39	0.27
Nd_2O_3	0.21	0.05	0.05	0.06	0.04	0.09	0.17	0.11
F	0.79	0.80	0.57	0.74	0.79	0.74	0.83	0.60
Cl	0.03	0.04	0.06	0.01	0.03	0.04	0.03	0.05
Total	91.82	92.24	91.59	93.89	93.11	93.45	94.11	90.80
Structural formulae based on 25 oxygens								
Si	0.830	0.831	0.687	0.531	0.482	0.560	0.677	0.743
Fe	0.098	0.072	0.040	0.017	0.012	0.046	0.067	0.022
Mn	0.005	0.005	0.008	0.004	0.001	0.000	0.006	0.006
Mg	0.248	0.252	0.089	0.055	0.044	0.057	0.217	0.079
Ca	10.280	10.327	10.743	10.547	10.488	10.602	10.447	10.903
Sr	0.049	0.047	0.047	0.051	0.055	0.057	0.051	0.071
U	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
P	5.041	5.037	5.059	5.286	5.353	5.217	5.112	4.955
La	0.011	0.008	0.015	0.011	0.016	0.023	0.015	0.005
Ce	0.015	0.018	0.015	0.018	0.018	0.023	0.026	0.019
Nd	0.014	0.003	0.003	0.004	0.003	0.006	0.011	0.007
Fe	0.460	0.464	0.335	0.419	0.455	0.425	0.473	0.356
Cl	0.008	0.013	0.019	0.003	0.008	0.013	0.008	0.015
Total	17.057	17.078	17.062	16.946	16.933	17.027	17.110	17.179

* Total iron calculated as FeO.

Table 3.10. Compositions of individual garnets from Peter I, II, and K-L, and their Dawson and Stephens (1975) designation.

wt. %	1	2	3	4	5	6	7	8	9
	G11	G11	G5	G5	G5	G5	G5	G5	G5
SiO_2	40.69	40.60	35.55	37.22	37.32	37.36	37.45	37.50	37.90
TiO_2	0.52	0.49	0.13	0.12	0.13	0.12	0.12	0.11	0.05
Al_2O_3	17.73	17.56	21.33	22.57	22.44	22.52	22.91	21.83	22.79
Cr_2O_3	7.04	7.08	0.03	0.05	0.05	0.06	0.05	0.07	0.09
FeO*	6.47	6.52	28.77	33.68	33.46	33.43	33.75	33.58	30.10
MnO	0.27	0.26	13.00	0.26	0.26	0.27	0.25	0.27	0.63
MgO	20.02	20.08	0.57	6.36	6.30	6.34	6.32	6.44	7.85
CaO	5.93	5.96	0.33	0.89	0.93	0.90	0.95	0.89	1.65
NiO	0.02	0.03	0.09	0.08	0.06	0.07	0.08	0.06	0.07
Na_2O	0.03	0.03	0.04	0.00	0.01	0.02	0.00	0.02	0.00
Total	98.72	98.60	99.84	101.22	100.94	101.08	101.87	100.76	101.12
Structural formulae based on 12 oxygens									
Si	2.982	2.981	2.933	2.910	2.923	2.921	2.908	2.945	2.925
Ti	0.029	0.027	0.008	0.007	0.008	0.007	0.007	0.007	0.003
Al	1.532	1.520	2.075	2.081	2.071	2.076	2.096	2.021	2.073
Cr	0.408	0.411	0.002	0.003	0.003	0.004	0.003	0.005	0.006
Fe	0.397	0.401	1.986	2.203	2.192	2.186	2.191	2.206	1.943
Mn	0.017	0.016	0.909	0.017	0.017	0.018	0.016	0.018	0.041
Mg	2.187	2.198	0.070	0.742	0.736	0.739	0.731	0.754	0.903
Ca	0.466	0.469	0.029	0.074	0.078	0.075	0.079	0.075	0.136
Ni	0.001	0.002	0.006	0.005	0.004	0.005	0.005	0.004	0.005
Na	0.004	0.004	0.007	0.000	0.002	0.003	0.001	0.002	0.000
Total	8.022	8.029	8.024	8.042	8.033	8.033	8.036	8.037	8.033
mg	0.846	0.846	0.034	0.252	0.251	0.253	0.250	0.255	0.317

* Total Fe expressed as FeO; 1-2, average of 4 and 3 analysis from a single grain; 3, average of 2 analyses; 4, average of 2 analyses; 5-7; single analysis; 8, average of 2 analyses; 9, single analysis.

Table 3.10. (continued).

wt. %	10 G1	11 G5	12 G5	13 G5	G1**	G5**	G11**
SiO_2	40.49	38.24	37.69	36.80	-	-	-
TiO_2	0.54	0.07	0.10	0.11	0.31-0.87	0.00-0.35	0.21-0.80
Al_2O_3	22.34	23.32	21.47	21.81	-	-	-
Cr_2O_3	1.06	0.07	0.04	0.03	0.00-3.67	0.00-0.13	5.60-13.55
FeO*	9.70	28.52	37.58	38.60	6.15-12.18	24.96-29.94	4.65-11.35
MnO	0.47	0.27	0.20	0.31	-	-	-
MgO	17.81	9.92	2.79	1.26	16.20-22.20	5.26-10.90	11.40-20.44
CaO	7.02	1.12	1.13	3.57	3.74-6.83	1.07-5.66	5.90-15.40
NiO	0.02	0.05	0.05	0.00	-	-	-
Na_2O	0.06	0.01	0.00	0.01	-	-	-
Total	99.53	101.60	101.05	102.50	-	-	-
Structural formulae based on 12 oxygens							
Si	2.941	2.904	3.005	2.932	-	-	-
Ti	0.030	0.004	0.006	0.007	-	-	-
Al	1.913	2.087	2.016	2.049	-	-	-
Cr	0.061	0.004	0.003	0.002	-	-	-
Fe	0.589	1.811	2.504	2.572	-	-	-
Mn	0.029	0.018	0.013	0.021	-	-	-
Mg	1.929	1.123	0.331	0.150	-	-	-
Ca	0.546	0.091	0.097	0.305	-	-	-
Ni	0.001	0.003	0.004	0.000	-	-	-
Na	0.008	0.001	0.001	0.002	-	-	-
Total	8.047	8.047	7.980	8.038	-	-	-
mg	0.766	0.383	0.117	0.055	-	-	-

* Total Fe expressed as FeO; 10-11, average of 2 analyses; 12-13, average of 3 analyses. ** Garnets from Dawson and Stephens (1975) and their oxide wt. % ranges: Titanian Pyrope (G1); Magnesian Almandine (G5); and Titanian Uvarovite Pyrope (G11).

CHAPTER 4

GEOCHEMISTRY

Whole-rock samples were analysed at Activation Laboratories Ltd., Ancaster, Ontario, for major and trace elements. Major elements were determined by X-ray fluorescence spectroscopy (XRF), along with a suite of 43 trace elements obtained by Fusion-ICP/MS (inductively coupled plasma-mass spectrometry) with elements, detection limits, and associated errors listed in Appendix II.

The application of geochemical data in the study of kimberlites is problematic because of the hybrid characteristics of the magma (primary minerals + xenocrysts derived from various sources), devolatilization of the magma during emplacement, and by the likely occurrence of contamination by crustal material and(or) groundwater (Mitchell, 1986). As a result, bulk compositions of kimberlites do not reflect that of their parental magmas. Geochemical studies have been conducted by previous workers on diatreme facies rocks and included autoliths, and on hypabyssal dykes and sills. In each case the work is of limited utility. For example, diatreme facies rocks contain abundant crustal xenoliths and invariably have experienced weathering and(or) alteration from groundwater, and degassing of the magma upon emplacement. Therefore, the bulk compositions of diatreme facies rocks represent a mixture of the magmas hybrid characteristics plus the characteristics of secondary phases and relict residual primary phases. Hypabyssal facies rocks generally contain fewer crustal xenoliths and are less contaminated, but are affected by shallow differentiation within these systems, rendering extrapolation of their compositions back to a parental magma problematical (Mitchell, 1986).

An understanding and appreciation for these problems has led workers to develop ways to evaluate the effects of contamination and alteration on the compositions of analysed kimberlites. Ilupin and Lutts (1971) reasoned that because crustal rocks contain greater amounts of Si and lower Mg than is typical of ultramafic rocks such as kimberlites, the Si/Mg (molar) should reflect the extent of crustal contamination. They proposed that a Si/Mg > 0.88 indicate contamination of the kimberlite by crust. Fesq et al. (1975) modified this criterion on the basis that olivine (Fo_{87}-Fo_{93}, Si/Mg ~ 0.60) and phlogopite (Si/Mg ~ 1.21) may constitute the bulk of the silicate groundmass, therefore, Si/Mg in excess of 1.2 indicates crustal contamination. Clement (1982) introduced a contamination index (C.I)= $(SiO_2 + Al_2O_3 + Na_2O)/(MgO + 2K_2O)$, which judges the effects of crustal contamination and(or) weathering. He reasoned that values for C.I close to unity are uncontaminated or fresh kimberlite, and that contamination and(or) weathering will result in increased SiO_2, Al_2O_3, and Na_2O contents relative to fresh(pristine) kimberlite, thereby increasing the values of C.I. This index cannot, however, take into account contamination of the kimberlite by xenocrystic olivine (Mitchell, 1989).

Modification of the composition of the kimberlite by differentiation processes must also be considered. Processes such as flow differentiation may concentrate macrocrystal and microphenocrystal olivine, which lead to increased SiO_2 and MgO contents relative to non-differentiated kimberlite (Mitchell, 1986). Differentiation may also produce carbonate-rich residua (in evolved kimberlites), which are depleted in SiO_2 and MgO, and enriched in CaO, CO_2, and H_2O relative to undifferentiated kimberlites (Mitchell, 1989, 1986). The effects of differentiation on C.I are negligible, as illustrated by comparing analyses of the olivine-rich core and the more evolved carbonate-rich margin of a single kimberlite dyke (Table 4.1 anal. 9-10). The samples differ considerably in SiO_2, MgO, and CaO, but their C.I values are similar.

Despite all the uncertainties associated with geochemical data for kimberlites, they were used in this study to show the compositional variation between the Meliadine kimberlites and to compare these with other kimberlites. With respect to the latter, if one considers a samples phenocryst/megacryst content and degree of differentiation, you can demonstrate differences in geochemistry relative to petrographically similar samples.

Major Elements

In general, kimberlites are considered to be undersaturated ultrabasic rocks (SiO_2= 25-35 wt. %) that have extremely low Al_2O_3 (< 5 %) and Na_2O-contents relative to other basic and alkaline ultrabasic rocks (Mitchell, 1989). Major element compositions for Meliadine kimberlites are listed in Table 4.1. Negligible contamination by crustal material is inferred because of the absence of visible country rock xenoliths in analysed samples, low Si/Mg, and C.I values near unity for the majority of samples. The K-L dykes however, do show higher C.I values (mean 1.32, range 1.23-1.36) and Si/Mg (mean 0.93, range 0.86-0.98) relative to Peter C.I (mean 1.04, range 1.02-1.06) and Si/Mg (mean 0.77, range 0.75-0.79) values.

A major process that has affected the major element contents of the dykes is differentiation. All Meliadine samples have evolved characteristics, being carbonate-rich with low SiO_2 and MgO, and high CaO and CO_2 contents (Table 4.1; Figure 4.1). Peter is the most evolved of the Meliadine kimberlites with the lowest SiO_2 (mean 14.46, range 13.60-15.09), and

MgO (mean 14.43, range 14.12-14.99), and the highest CaO (mean 24.75, range 22.95-26.28), and CO_2 (mean 24.82, range 17.35-29.50) concentrations compared to the K-L dykes. The composition of the K-L dykes have higher SiO_2 (mean 18.77, range 16.83-21.80), and MgO (mean 15.55, range 14.31-17.16), and high CaO (mean 20.73, range 18.65-22.34), and CO_2 (mean 15.34, range 13.76-16.25) compared to Peter. These differences in major element geochemistry reflect differences in olivine/groundmass carbonate, with Peter containing the greatest proportion of groundmass carbonate compared to K-L. Comparable evolved carbonate-rich kimberlite sills from Benfoentein, South Africa, West Greenland kimberlite dykes, and carbonate-rich dykes, South Africa are listed in Table 4.1, with all samples displaying the same characteristics of decreased SiO_2 and MgO, and higher CaO, CO_2, and H_2O relative to less evolved kimberlites.

Compositional variation in major element geochemistry between the Meliadine dykes is pronounced, which is consistent with the observed mineralogical differences between samples. For example, the presence of phlogopite in Peter is reflected in an increase in K_2O-contents (mean 0.64, range 0.56-0.78) relative to the non mica-bearing K-L dykes (mean 0.20, 0.17-0.24). P_2O_5-contents for Peter (mean 0.82, range 0.75-0.96) are lower than those of K-L (mean 1.12, range 0.96-1.33), which corresponds to the higher abundance of apatite observed in K-L. LOI-contents are greater in Peter (mean 31.26, range 30.50-31.70) over K-L (mean 28.04, range 27.13-29.15), which are attributed to larger amounts of groundmass carbonate.

Compatible Trace Elements

Compatible trace element abundances for Meliadine dykes are listed in Table 4.2. By definition, these elements are extracted preferentially by crystallizing minerals, and are consequently depleted in the residual liquid during fractional crystallization. In kimberlites, compatible elements are primarily hosted in olivine (Ni, Co, Sc), spinel (Cr, Ni, Cu, Co, Sc, V, Zn), perovskite (Sc), sulphides (Ni, Cu), diopside (Cr, Sc, V, Ni), and phlogopite (Cr, Sc) [Mitchell, 1989]. Abundances of these elements in whole-rock analyses increase with increasing modal proportions of olivine and spinel, and decrease with crustal contamination (Fesq et al., 1975), and therefore, do not represent the composition of the primary magma (Mitchell, 1989).

Meliadine kimberlites are low in compatible element abundances, especially Cr (mean 389, range 240-478 ppm) and Ni (mean 646, range 586-787 ppm) relative to average worldwide kimberlite (Cr= 893 ppm; Ni= 965 ppm; Table 4.2), and various South African kimberlites. This depletion is characteristic of evolved carbonate-rich kimberlites relative to less evolved kimberlites (compare anal. 2a, b, and 3a, b in Table 4.2) [Scott, 1979; Mitchell, 1989].

Incompatible Trace Elements

Incompatible elements are concentrated preferentially in the liquid phase during crystallization, and are generally not removed from the liquid until the later stages of groundmass crystallization in kimberlites (Mitchell, 1986, 1989). Their abundances in whole-rock samples can be decreased by crustal contamination and(or) by the presence of olivine macrocrysts and groundmass spinels (Mitchell, 1989, 1986). Fesq et al. (1975) and Kable et al. (1975) concluded that Ti, Nb, Ta, Zr, Hf, P, and REE are insignificantly affected by crustal contamination and therefore inter-element relationships remain unaffected and may be used to obtain information on the source regions of kimberlites (Mitchell, 1989, 1986). Such an assumption is valid however only if the concerned ratios are identical for the contaminant and the kimberlite, or much higher in the kimberlite. The principal incompatible elements and their hosts used in this study are (Mitchell, 1989): Ba-Rb (phlogopite), Sr (apatite, perovskite, diopside, carbonate), Zr-Hf (perovskite, macrocrystal ilmenite), Nb-Ta (perovskite, macrocrystal ilmenite), Th-U (perovskite, apatite), REE (perovskite, apatite, carbonates).

The incompatible trace element geochemistry for the Meliadine kimberlites is similar to that found in other evolved carbonate-rich kimberlites (Table 4.2 anal. 2a, b, and 3a, b), except that the abundances for HREE and Th contents are enriched. Compared to average worldwide kimberlite (Table 4.2 analysis 1) Meliadine dykes are enriched in Sr, Y, Nb, Th, U, and depleted in Rb. Similar enrichments of these elements are observed in other evolved carbonate-rich kimberlites relative to their less evolved counterparts (Table 4.2). Scott (1979) attributed the observed increase in incompatible elements in the carbonate-rich Holsteinsborg dykes (Table 4.2, analyses 3a-3b) to be related to the carbonate fraction of these rocks. Incompatible elements may have been concentrated by the volatile fraction (CO_2) of the magma. Nixon et al. (1981) further noted that closed system behaviour in hypabyssal kimberlites makes such samples relatively enriched in incompatible trace elements compared to associated pipes that did not act as closed systems because of loss of volatiles such as CO_2.

Barium, Rubidium, and Strontium Phlogopite is the principal host for Ba and Rb, consequently, the mica-bearing Peter dykes display higher concentrations of Rb (mean 44, range 42-47 ppm) relative to K-L (mean 19, range 12-23 ppm). Low Rb contents are observed in other evolved carbonate-rich kimberlites (Table 4.2), reflecting the abundance of carbonate, which does not host Rb. Ba-contents do not follow the same trend as Rb, and are greater in K-L (mean 1076, range 821-1218 ppm) than in Peter (mean 780, range 732-859 ppm). This difference is consistent with the greater abundance of fine-grained, late stage barite in the groundmass of K-L dykes, not to phlogopite content. With the dominance of carbonate in the Meliadine dykes, Sr-contents are high (mean 1311, range 1195-1482 ppm). High Sr-contents are characteristic of evolved carbonate-rich kimberlites (Scott, 1979).

Zirconium, Hafnium, Niobium, and Tantalum Consistent Zr/Hf of 34-45 for Meliadine dykes is observed, which are similar to worldwide kimberlites [33; Mitchell, (1986)], kimberlites from Russia [30-60; Kamenskii et al., (1977)], and South African kimberlites and orangeites [41-48; Kable et al., (1975)]. Zr/Hf for kimberlites are also similar to a wide variety of other mantle derived rocks and continental crust. Nb abundances in Meliadine dykes range from 167-252 ppm (mean of 214), which are higher than the average value for worldwide kimberlites (141 ppm, Table 4.2). Increasing Nb has been correlated with increasing Ti, consistent with increases in the modal abundance of groundmass Ti-rich oxides such as ilmenite (Mitchell, 1995b). This relationship is however not observed in the Meliadine samples. The presence of groundmass perovskite in K-L and its absence in Peter results in lower average Ta-contents in Peter (mean 5.6, range 2-9 ppm) compared to K-L (mean 9, range 6-11 ppm).

Thorium and Uranium Abundances of Th and U are significantly higher in Peter (Th= 220-310 ppm; U= 15-25 ppm) than in the K-L dykes (Th= 26-61 ppm; U= 5-6 ppm). Th/U from Peter is 12-16 whereas K-L have ratios of 5-11 more closely resembling the worldwide ratio of 5 (Table 4.1). Higher Th in the Peter dykes may be attributed to apatite. Fesq et al. (1975) reported that South African kimberlites (Premier, Koffyfontein, and Bellsbank) have Th/U of 4-9, with the exception of the apatite-rich Main Fissure dyke, Bellsbank, with Th/U of 42-40 [Th (630-920 ppm), U (15-22.9 ppm.

Incompatible element geochemistries for Meliadine dykes are plotted in primitive mantle-normalized trace element variation diagrams [Fig. 4.2; normalizing values from Sun and McDonough, (1989)]. The relative order of elements in this diagram are of increasing compatibility from left to right in a four phase lherzolite (olivine + orthopyroxene + clinopyroxene + garnet) undergoing partial fusion (Wilson, 1989). Such plots give gently, positively sloping patterns for average MORB (cf. Sun and McDonough, 1989). Thus, magmas derived from sources differing from primitive mantle (PM) will give "sawtoothed" patterns with some elements displaying enrichments or depletions relative to neighbouring elements. This sawtooth pattern implies that the source region differs compositionally from PM, possibly as a result of a metasomatic enrichment event. Plots such as Figure 4.2 are useful in illustrating similarities and differences between mantle derived magmas, although, inferences regarding source regions may not be realistic. Interpretation of these so-called anomalies is subjective (bearing in mind the previous statement), but negative anomalies are commonly interpreted to result from a residual phase within the source region that is retaining the element(s) in question (Mitchell, 1995b). Alternatively, depletion of the element(s) in the magma may reflect intrinsic depletion of the element(s) in the source region, or may result from processes involved in the generation of the magmas (Mitchell, 1995b). Depletions/enrichments may also result from differentiation. Oxide crystallization and segregation prior to dyke emplacement may cause Ti-depletions, and concentration of apatite may result in Th-enrichment. It should be noted that analytical error can also introduce spurious anomalies. Significant anomalies resulting from analytical uncertainties in the Meliadine samples are not observed. Errors associated with normalized element abundances in Figure 4.2 are as follows: ± 10-15 % for Rb, Y, and Hf, and ± < 5 % for the remaining elements (cf. Appendix II for details). Analytical uncertainties are therefore insignificant and will not be considered further.

The distribution patterns for Meliadine dykes (Fig. 4.2) are in general similar, characterized by prominent negative Rb, K, and Ti anomalies, and positive Th and U anomalies. Enrichments of HREE (Tb, Er, Tm, and Yb) occur in Peter over K-L, and weak negative Sr and Ta anomalies are a feature of all dykes. Negative Rb and K anomalies are characteristic of kimberlites and are conventionally attributed to the presence of residual phlogopite in the mantle source (Mitchell, 1995b; Sun and McDonough, 1989). K and Rb in Peter are higher than for K-L, which may reflect varying degrees of partial melting, or a difference in the amount of K in the protolith. The Ti anomalies may be explained by a residual titanate (sphene, rutile, ilmenite, etc.) phase in the source region. Alternatively, the anomaly may be caused by enrichment of the neighbouring elements Tb, Y, Er, and Yb relative to Ti such that the anomaly is an artifact of this enrichment process. Kimberlites characteristically do not display Ti-depletion, and enrichment in the elements Tb through to Yb. Positive Th-U anomalies are observed in all Meliadine dykes with extreme enrichment in Peter of 2500-3600 times PM (Th) and 700-1200 times PM (U). The anomalies may result from a source enrichment if the source region contained a Th-U bearing phosphate phase (Kable et al., 1975), or the presence of apatite in the samples. The cause for the negative Ta anomalies are unknown.

The weak negative Sr anomaly is unlikely caused by a residual phosphate in the source region, as there is no associated negative P anomaly. The Sr anomaly could be the result of a depletion in clinopyroxene within the source resulting from previous basaltic extraction events (Mitchell, 1995b). Independent evidence in support of this however, is lacking.

The overall trace element patterns for the Meliadine dykes is similar to those of on- and off-craton Group I kimberlites from South Africa (Fig. 4.2). This similarity suggests that the source regions and(or) partial melting process involved in the generation of the Meliadine kimberlites is comparable to that of Group I kimberlites in South Africa. For comparison, olivine melilites, average lamproite, and Hawaiian alkalic lavas (Fig. 4.3) show how trace element plots are diagnostic for different magma types.

Rare Earth Elements (REE) REE in kimberlites are concentrated in late crystallizing minerals such as apatite, perovskite, and carbonates (Fesq et al., 1975; Mitchell, 1986). Individual kimberlites exhibit a wide variation in ΣREE contents with most being characterized by simple linear REE distribution patterns displaying strong LREE (La to Sm) enrichment relative to HREE (Gd to Lu) [Mitchell, 1986; 1989]. Emplacement style of kimberlites (diatremes versus dykes) also affects the ΣREE in kimberlites. Hypabyssal facies archetypal kimberlites and orangeites contain significantly greater ΣREE than diatreme facies kimberlites (Mitchell, 1986). Strongly LREE-enriched patterns are not restricted to kimberlites, but are also found in lamproites and highly undersaturated potassic lavas (Mitchell, 1986).

Table 4.3 contains REE abundances for Meliadine dykes and plotted in Figure 4.4 are the representative REE distribution patterns for the dykes. Normalized La/Yb [$(La/Yb)_N$] for K-L ranges from 22-53, whereas in Peter this ratio is 5-7; lower ratios which result from HREE-enrichment. $(La/Yb)_N$ for average worldwide kimberlite are approximately 70. Meliadine kimberlites contain ΣREE abundances (mean 562, range 416-645 ppm) similar to the worldwide average of 486 ppm (Table 4.2), although K-L 2B-6 is ~ 1/3 lower in ΣREE relative to all other Meliadine dykes. The Meliadine dykes show LREE-enrichment typical of average kimberlite, but they have U-shaped patterns, with HREE (Gd to Lu) being more enriched relative to average kimberlite.

Modification of the typical LREE-enriched REE patterns can result from crustal contamination if the material being assimilated is high in HREE. Contamination of the kimberlite by average post-Archean shales or average continental crust (Fig. 4.5A) will alter the REE patterns of kimberlites by diluting LREE contents and increasing HREE to give a flat pattern through Gd to Lu, and a slight negative Eu anomaly. The extensive enrichment in HREE observed in Peter cannot be explained by assimilation of crustal material. On the other hand, K-L does show a flattening of the REE pattern from Dy to Lu that would be consistent with assimilation of crustal material. This interpretation is however not supported by major and trace element data (discussed below).

The lack of visible crustal xenoliths in samples selected for this study, the low Si/Mg and the low C.I indicate that crustal contamination is an unlikely possibility to account for the observed enrichment in HREE. Low abundances of SiO_2 (13.60-21.80 wt. %), Al_2O_3 (1.14-1.81 wt. %), and Na_2O (0.40-0.88 wt. %) combined with high Ni (586-787 ppm) and Cr (240-278 ppm) preclude extensive assimilation of crustal material based on published average compositions (Tables 2.15, 3.5, and 4.4 in Taylor and McLennan, 1985). Further, relatively non-radiogenic Sr and radiogenic Nd combined with high abundances of incompatible elements (e.g., LREE, Sr, Ba, Th, Zr, Nb, etc.) are not characteristic with crustal assimilation, which would increase $^{87}Sr/^{86}Sr$ and decrease ε_{Nd}. Therefore, trace element concentrations in Meliadine kimberlites are not the result of crustal contamination.

Enrichment in HREE observed in the Meliadine dykes (specifically Peter) may be attributed to: (1) unusual source mineralogy or geochemistry; (2) the partial melting process; (3) operation of another process such as differentiation and(or) immiscibility of silicate and carbonate liquids; (4) concentration of garnet (HREE-bearing phase) which was not fractionated(removed) from the magma; and (5) post magmatic enrichment.

The observed REE patterns for the Meliadine kimberlite dykes may be inherited from the source region. Prinzhofer and Allègre (1985) obtained REE abundances for ophiolitic melt residues (dunites and harzburgites) with U-shaped REE distribution patterns similar to those of Peter (compare Figs. 4.4 and 4.5B). Chondrite normalized values for the ophiolitic residues are however extremely low compared to Meliadine samples. Melting of such a source with low REE abundances would require extremely low degrees of partial melting (< 0.05 %) to acquire the observed abundances of HREE in Meliadine samples (specifically Peter II).

Melt fraction calculations were based on the following equation (Berthelot-Nernst):

$$C_L/C_O = 1/F + D(1 - F)$$

C_O and C_L are concentrations of the trace element in solid and initial liquid respectively; F is the degree of partial melting; and D is the bulk distribution coefficient. Assuming complete incompatibility in the melt fraction calculations (D = 0), the Berthelot-Nernst equation reduces to

$C_L/C_O = 1/F$. Calculated melt fractions represent maximums, however, melt fractions will be lower for $D > 0$.

Extremely small melt fractions may occur (McKenzie 1989; Hunter and McKenzie, 1989), although separation from the source is inhibited because such small melt fractions cannot transport significant heat, so that the melts solidify within the lithosphere before surface is ever reached (McKenzie, 1989). It is unlikely therefore that the Meliadine kimberlites inherited their U-shaped REE patterns from a source consisting of depleted ophiolitic residues with similar U-shaped REE profiles. A multi-stage melting event however, in which the depleted residues are re-melted may result in a magma with a high concentration of HREE.

Differentiation toward carbonate-rich evolved kimberlite has been shown to increase incompatible element abundances in more evolved carbonate-rich kimberlites relative to carbonate-poor varieties. I was unable to find published HREE data for evolved kimberlites, prohibiting comparison of the observed enrichments seen in Peter and K-L to other evolved kimberlites.

A potential process of differentiation is the possible role of silicate-carbonate liquid immiscibility. Wendlant and Harrison (1979) demonstrated that the HREE are preferentially enriched in carbonate melt relative to the coexisting silicate melt. These authors also found that a CO_2-rich vapour phase coexisting with the carbonate melt will be further enriched in REE, specifically the LREE. Therefore, the HREE-enrichment observed in the Meliadine dykes might be attributed to silicate-carbonate immiscibliity and the ability of the carbonate melt to concentrate HREE. Possible evidence for liquid immiscibility is found in groundmass material of the K-L 2A-2B dykes. Two distinct types of groundmass material are present (GM1 and GM2). These may have formed directly by separation of a carbonate melt from the silicate fraction, or by the progressive evolution of the silicate-carbonate liquid to a carbonate-rich residua (cf. Chapter 3).

Enrichment of HREE by silicate-carbonate liquid immiscibility is possibly supported by two calcite-rich kimberlites from the Koidu kimberlite complex, West African craton. Relative to the average Koidu kimberlite, the Koidu calcite kimberlites (Tables 4.2 anal. 7d-7e, and 4.3 anal. 4-5) are richer in Sr, Y, and HREE. Taylor et al. (1994) suggests that the carbonate-rich Koidu kimberlites are not simply residual melts of a kimberlite that had fractionated olivine, but rather were derived from a volatile-rich (CO_2) melt in which a secondary carbonation event occurred during a late stage deuteric alteration. Late-stage separation of a carbonate-rich fraction from the kimberlite melt may have caused the observed enrichments in Sr and Ba (Taylor et al., 1994), and possible enrichments in HREE. The Koidu kimberlites contain essentially identical LREE-contents regardless of carbonate content, but HREE-enrichment is only observed in the calcite-rich kimberlites. Liquid immiscibility could lead to the observed HREE-enrichments. The enrichment of HREE in the Koidu calcite kimberlites is on a much smaller scale however than that observed in the Meliadine dykes (compare Figs. 4.4 and 4.6).

A conceptual model to illustrate this process would be to begin with the melting of a carbonated lherzolite source to produce a CO_2-rich undersaturated silicate melt (Wyllie, 1980, 1987, 1989a,b; Wyllie et al., 1990; Brey et al., 1983; Canil and Scarfe, 1990). During ascent, the magma may intersect a silicate-carbonate melt miscibility gap whereupon the immiscible carbonate melt, once formed, may wholly or partially separate from the silicate melt. Upon separation, HREE will partition into the carbonate liquid. Separation of the immiscible melts could also occur once the magam is emplaced. Because the carbonate fraction is less viscous (Dobson et al., 1996) than the associated silicate melt, the carbonate fraction may therefore migrate upwards more rapidly. During this process more dense mineral phases (e.g., xenoliths, xenocrysts, diamond, etc.) will remain behind, being removed from the rapidly ascending carbonate fraction. Alternatively, in situ differentiation may occur such as in the Benfontein sills, Kimberly, South Africa. Here highly evolved carbonate-rich sills contain Cr-pyrope garnet, Cr-diopside, picroilmenite, and diamond (Dawason and Hawthorne, 1973). Removal of phases in a sill environment (horizontal emplacement) is not possible as the dense phases in question will settle-out but remain in the sill. The Benfontein sills may represent the separation of immiscible melts once the magma was emplaced. In steeply dipping dykes dense mineral phases will be removed such as in the Meliadine dykes. Once the liquid is emplaced crystallization of silicates (olivine, spinel, perovskite, apatite), and carbonates (calcite) can occur, resulting in the observed major and trace element concentrations.

Incorporation of garnet, which is an effective concentrator of HREE, may also account for the observed HREE-enrichment. If this phase was not wholly removed from the magma by differentiation, concentration of residual garnets could alter the bulk-rock REE distribution pattern. REE abundances were not analysed for the recovered Meliadine garnets, therefore REE concentrations for an almandine in a rhyolite from Coburn Mountain, Main USA (listed below; Irving and Frey, 1978) will be used to illustrate the effects such a phase will have on the bulk-rock REE patterns for the Meliadine dykes:

Coburn Mountain garnet REE concentrations (ppm)

La	Ce	Pr	Nd	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu
42.6	172	-	63	17.7	0.55	62	17.9	-	55.2	-	-	194	28.5

Coburn Mountain garnet is classified as a Group 5 magnesian almandine from Dawson and Stephens, (1975).

Calculations were based on the following assumptions: (1) contribution of HREE was solely from garnet; (2) calculations were modeled for Peter II, because this sample contained the greatest HREE abundances (Fig. 4.4); and (3) calculations were only carried out for Yb and Lu in order to determine the requisite amount of garnet (modal %) required to match Yb and Lu concentrations in Peter II.

The principle conclusions that can be drawn from such calculations are as follows. Firstly, the addition of 8 modal % garnet (Lu-calculation) or 7 modal % garnet (Yb-calculation) are required to obtain the observed concentrations of Lu and Yb respectively, in Peter II. Such modal abundances of garnet were not observed. Lastly, the calculated modal abundances of garnet will not yield U-shaped REE patterns, but flat patterns from Gd to Lu. Therefore, the addition of garnet to the give U-shaped REE patterns in the Meliadine kimberlite dykes is an implausible process.

The observed HREE enrichment in the Meliadine dykes cannot be explained satisfactorily by crustal contamination, derivation from a source with a similar a U-shaped REE profile, or incorporation of a HREE-bearing phase such as garnet. Liquid immiscibility may play a role in the HREE enrichment but data is lacking to adequately support such a theory. The HREE anomalies and their probable origin are therefore unexplainable at this time.

Strontium ($^{87}Sr/^{86}Sr$) and Neodymium ($^{143}Nd/^{144}Nd$) Isotopes

Isotopic work was conducted in the Radiogenic Isotope Facility in the Department of Earth and Atmospheric Sciences at the University of Alberta. All Meliadine kimberlite dykes were analysed for Rb-Sr and Sm-Nd using standard cation exchange chromatography and isotope dilution techniques (cf. Appendix III for details).

The isotope evolution of Nd within the Earth is modeled relative to the chondritic uniform reservoir (CHUR) model, in which it is assumed that terrestrial Nd has evolved through time in a uniform reservoir with Sm/Nd equivalent to that of chondrite meteorites (DePaolo and Wasserburg, 1976a). Samples from undifferentiated primitive mantle sources will have Sm/Nd equivalent to that of CHUR. Partial melting of CHUR-like mantle gives rise to magmas enriched in Nd relative to Sm (i.e., LREE-enriched, low Sm/Nd, and negative ε_{Nd} if isolated and left to evolve over time). The residual solids left behind after magma extraction have higher Sm/Nd (i.e., positive ε_{Nd}). Such residual regions within the mantle are termed "depleted" and show a long-term history of LREE and LILE (e.g., K, Rb, Sr, Ba, Zr, Th, etc.) depletion.

The results of the Rb-Sr and Sm-Nd isotopic measurements for the Meliadine dykes are tabulated in Table 4.4. Initial $^{87}Sr/^{86}Sr$ and ε_{Nd} (Fig. 4.7) were age corrected back to the time of emplacement of 192 Ma (cf. Chapter 5). Initial $^{87}Sr/^{86}Sr$ for the Meliadine dykes fall in a range of 0.70367 to 0.70526 (mean 0.70432). In detail, K-L dykes display lower, non-radiogenic initial $^{87}Sr/^{86}Sr$ (mean 0.70403, range 0.70367 to 0.70433) than Peter, which is slightly more radiogenic (0.70526). A positive correlation is observed with respect to initial $^{87}Sr/^{86}Sr$ and Sr-content (high $^{87}Sr/^{86}Sr$, low Sr, high Rb). The ε_{Nd} values for all dykes range from +2.2 to +5.2 (mean +4.0). As with initial $^{87}Sr/^{86}Sr$, ε_{Nd} values are greater for K-L (mean +4.6, range +4.8 to +5.2) relative to Peter (+2.2). No systematic correlations were observed for ε_{Nd} and Sm or Nd contents.

These data may be compared to South African kimberlites as summarized by Smith (1983). Smith (1983) subdivided southern African Cretaceous kimberlites into two distinct groups. The first group, termed Group I (Smith, 1983), are predominantly non-micaceous (archetypal kimberlites), 80-114 Ma kimberlites having ε_{Nd} values of –0.5 to +4.1, and generally non-radiogenic initial $^{87}Sr/^{86}Sr$ ranging from 0.7033 to 0.7049. Similar isotopic features have also been observed in occurrences from India, United States, Greenland, Zaire, and Russia (Basu and Tatsumoto, 1980; Weis and Demaiffe, 1985; Nelson, 1989). Kimberlites belonging to Group I are interpreted to have been derived from source regions that are relatively undifferentiated to slightly depleted (i.e., higher Sm/Nd, +ε_{Nd}) with respect to CHUR, similar to the source regions for oceanic island basalts (OIB) [Basu and Tatsumoto 1980; Smith 1983; LeRoex, 1986]. These characteristics are consistent with derivation from asthenospheric mantle. The second group, Group II (Smith, 1983) are phlogopite-rich kimberlites, subsequently relabeled orangeites by Mitchell (1995b), 114-150 Ma in age with ε_{Nd} values of –5.5 to –9.1, and relatively radiogenic initial $^{87}Sr/^{86}Sr$ of 0.7074 to 0.7109. Source regions for Group II kimberlites are thought to reside in the non-convecting continental lithosphere, with isotopic characteristics indicative of isolated ancient (1-2 Ga) metasomatic enriched regions (Smith, 1983; McCulloch et al., 1983).

The observed extreme enrichments in incompatible trace element abundances within Group I kimberlites (e.g., LREE and LILE) are in apparent contradiction with the longterm integrated history given by the isotope data, and therefore have been attributed to metasomatic enrichment of the source and(or) small degrees of partial melting shortly before magma generation. This mechanism supplies the incompatible elements, but consequent extraction of kimberlitic melts close in time to the metasomatic enrichment event prevents the development of a geochemically distinct (i.e., enriched) isotopic signature (Hawkesworth et al., 1987, references therein).

The isotopic results indicate that the Meliadine kimberlites were derived from a time-integrated LREE-depleted asthenospheric mantle source similar to that from which Group I kimberlites are derived. The Meliadine kimberlites can be sub-divided into two distinct isotopic groups. The first group consists of the K-L dykes, all of which display non-radiogenic initial $^{87}Sr/^{86}Sr$ (mean of 0.70403) and positive ε_{Nd} values (mean +4.6). Peter defines the second isotopic group (albeit a single sample) and consists of slightly more radiogenic initial $^{87}Sr/^{86}Sr$ (0.70526) and lower positive ε_{Nd} (+2.2). This difference may indicate isotopically distinct source regions, or a heterogeneous source.

Small-scale isotopic heterogeneities in the source region have been observed in the 71 Ma Mbuji Mayi kimberlites, Zaire, in which initial $^{87}Sr/^{86}Sr$ is relatively restricted (0.7040-0.7045) with variable positive ε_{Nd} values (+1.9 to +5.9) [Weis and Demaiffe, 1985]. Similarly, the 600 Ma kimberlites of central West Greenland display relatively consistent initial $^{87}Sr/^{86}Sr$ between 0.7028-0.7033, but variable ε_{Nd} of +1.3 to +3.9 (Nelson, 1989).

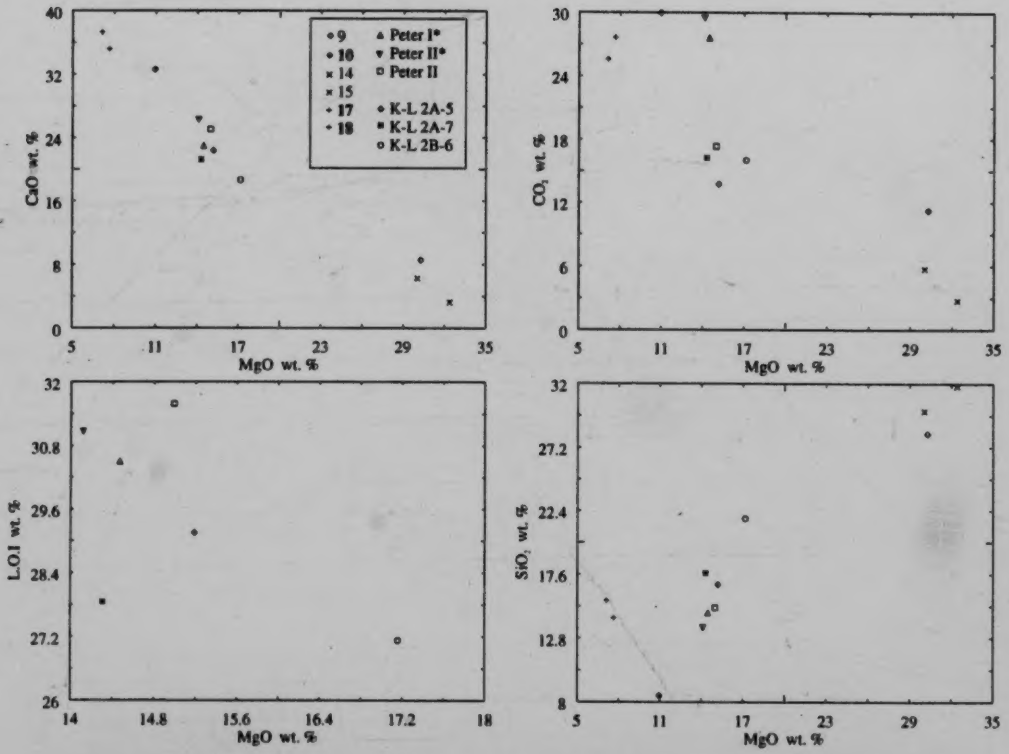


Figure 4.1. Selected major oxide (wt. %) variation diagrams for the Meliadine kimberlites and selected kimberlites from Greenland and West Africa (numbers from sample legend as from Table 4.1), plotted with MgO as the abscissa. * Indicates data from A.R Miller pers. commun. (1996).

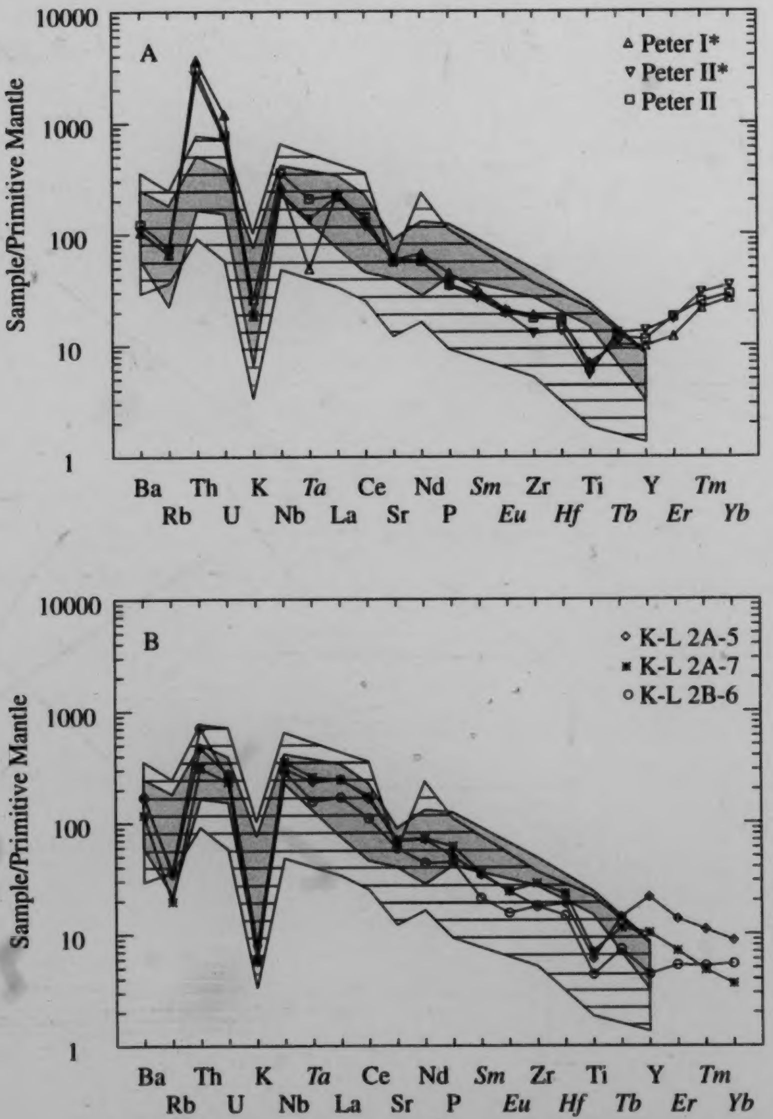


Figure 4.2. Primitive mantle normalized trace element distribution diagrams for Peter (A) and K-L (B) kimberlite dykes,with shaded and striped fields for on-craton and off-craton kimberlites, respectively [data from Smith et al., 1985]. Elements in italics not analysed for on and off-craton south African kimberlites. * Indicates data from A.R. Miller pers. commun. (1996).

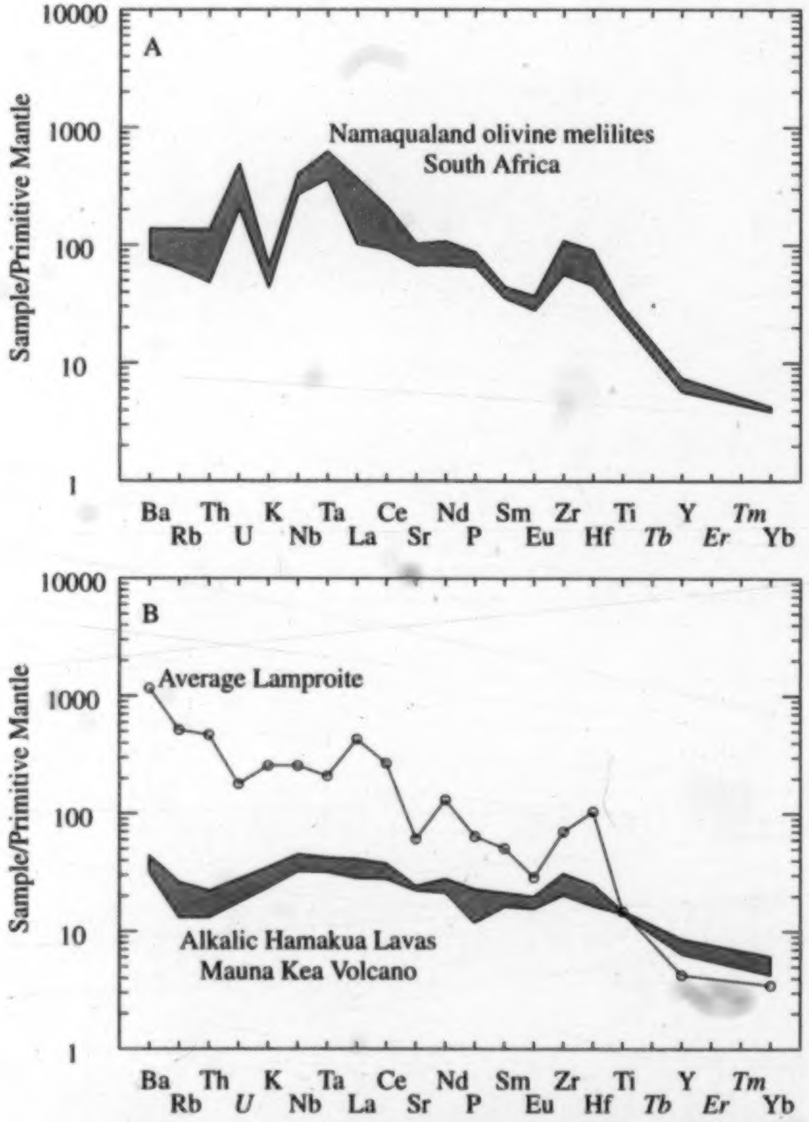


Figure 4.3. Primitive mantle normalized trace element distribution diagrams for range of six Namaqualand olivine melilites, South Africa (A) [Rogers et al., 1992], and average lamproite (Bergman, 1987) with range for alkalic lavas from the Hamakua Coast of Mauna Kea volcano: Laupahoehoe Gulch (Frey et al., 1991). Elements in italics not analysed for (except U in average lamproite).

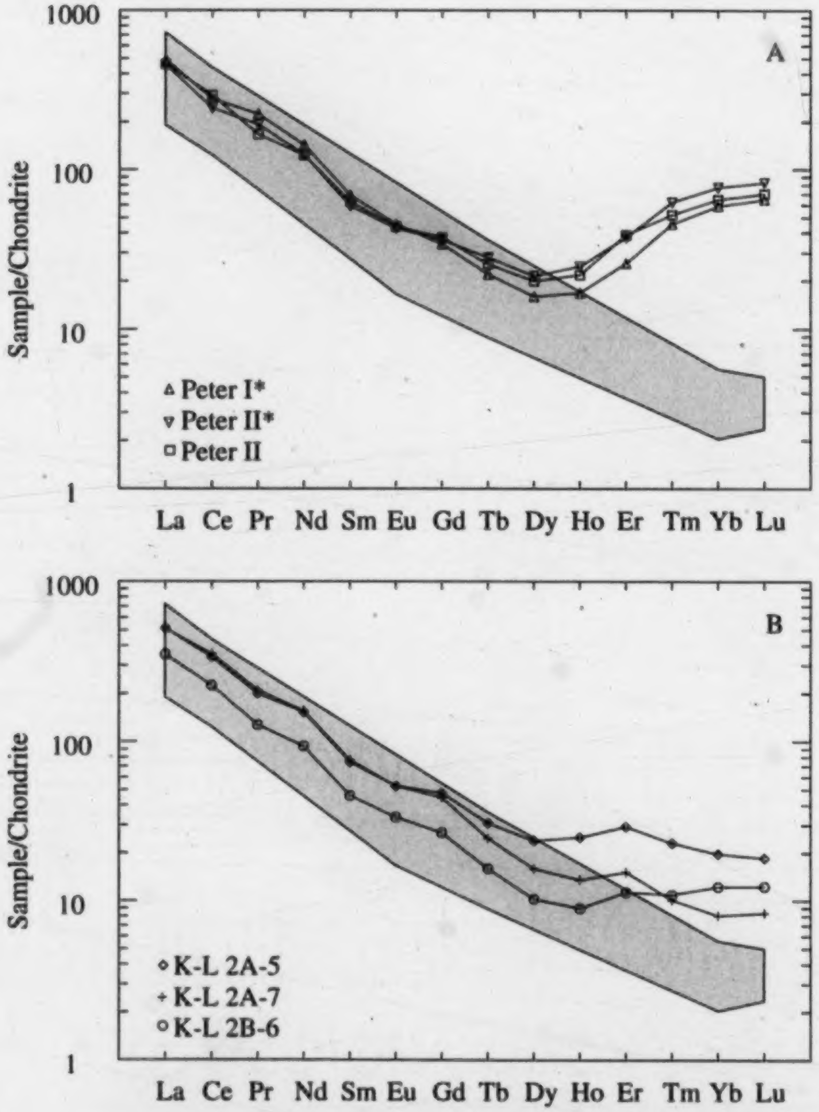


Figure 4.4. Chondrite normalized REE distribution diagrams for Peter (A) and K-L (B) kimberlite dykes relative to the generalized field for kimberlites [data from Mitchell, (1986); Mitchell and Brunfelt, (1975); * A.R. Miller, pers. commun., (1996)].

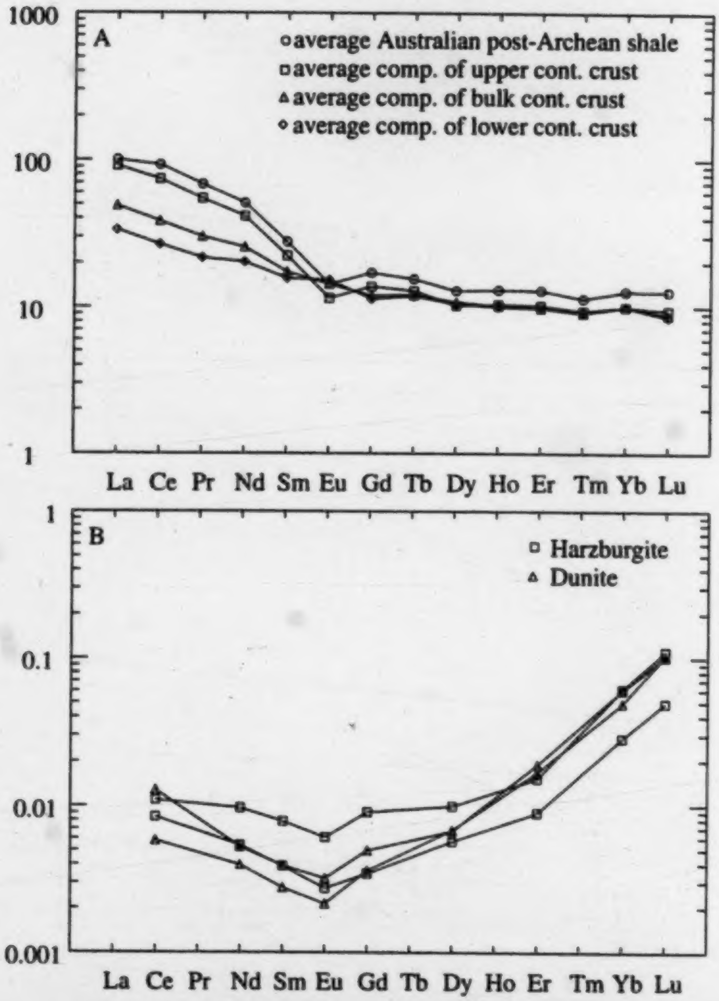


Figure 4.5. (A) Chondrite normalized REE distribution diagram for average Australian post-Archean shale (Nance and Taylor, 1976), average composition for the upper continental crust (Taylor and McLennan, 1985), average composition for bulk continental crust (Taylor and McLennan, 1985), and average composition of the lower continental crust (Taylor and McLennan, 1985). Assimilation of such material will reduce the overall concentration of LREE, and increase HREE to give a more flat pattern from Gd to Lu. Also note the characteristic negative Eu anomaly associated with crustal material. (B) Chondrite normalized REE distribution diagram for selected harzburgite and dunite ophiolitic melt residues (Prinzhofer and Allègre, 1985).

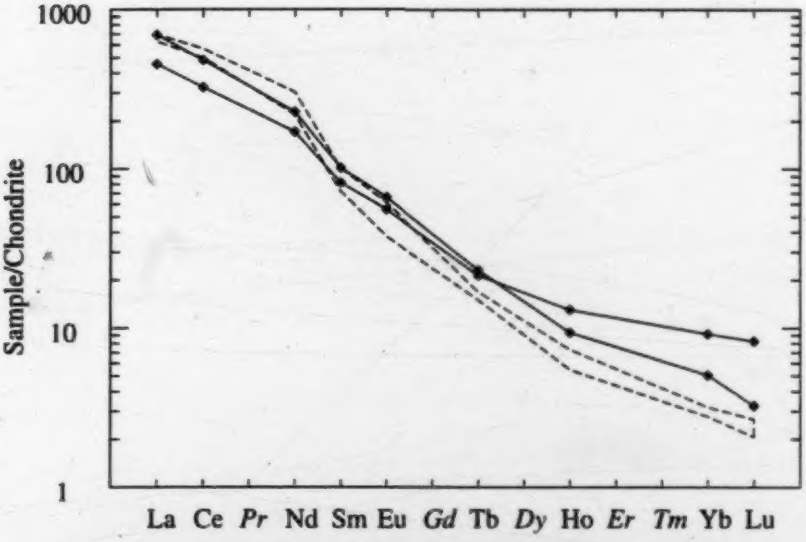


Figure 4.6. Chondrite normalized REE distribution diagram for Koidu calcite-rich kimberlites (filled diamonds) relative to the stippled field for Koidu hypabyssal kimberlites (data from Taylor et al., 1994). Abundances for LREE (La-Sm) are similar for calcite-rich and typical hypabyssal samples, whereas HREE (Gd-Lu) enrichment is only observed in the calcite-rich kimberlites. This enrichment may be attributed to silicate-carbonate liquid immiscibility. Elements in italics were not analysed for.

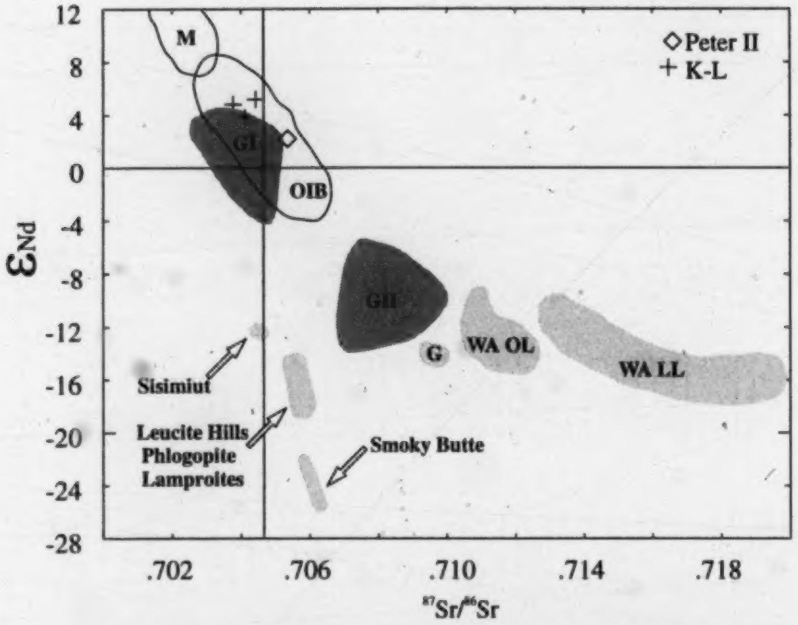


Figure 4.7. Initial isotopic compositions of Sr and ε_{Nd} for Meliadine kimberlite dykes relative to generalized fields for MORB(M), OIB, Group I Kimberlites (GI), Group II Kimberlites (GII), and lamproites: Gaussberg (G); Western Australia Olivine lamproites (WA OL); and Western Australia Leucite lamproites (WA LL). Generalized fields with data sources taken from Wilson (1989), Mitchell (1995b), and Mitchell and Bergman (1991).

Table 4.1. Major element compositions for Meliadine kimberlite dykes, and various kimberlites from around the world.

wt. %	**Peter II**	**Peter I***	**Peter II***	**K-L 2A-5**	**K-L 2A-7**	**K-L 2B-6**	1	2	3	4
SiO_2	15.09	14.70	13.60	16.83	17.69	21.80	30.00	27.60	32.80	33.00
TiO_2	1.33	1.50	1.18	1.31	1.52	0.95	1.80	1.60	0.45	0.37
Cr_2O_3	-	-	-	-	-	-	-	-	0.29	0.33
Al_2O_3	1.44	1.50	1.40	1.64	1.81	1.14	2.60	3.20	1.97	1.21
Fe_2O_3**	6.95	9.60	7.10	9.21	11.27	9.27	9.40	8.40	8.29	8.35
FeO	-	-	-	-	-	-	-	-	-	-
MnO	0.25	0.28	0.26	0.32	0.29	0.21	0.20	0.10	0.19	0.18
MgO	14.99	14.47	14.12	15.19	14.31	17.16	29.40	24.30	34.60	40.40
CaO	25.03	22.95	26.28	22.34	21.21	18.65	10.90	14.10	7.82	7.25
Na_2O	0.68	0.40	0.50	0.73	0.66	0.88	0.30	0.20	0.22	0.24
K_20	0.78	0.56	0.57	0.24	0.17	0.18	1.20	0.80	0.43	0.16
P_2O_5	0.76	0.96	0.75	1.07	1.33	0.96	1.60	0.50	0.74	0.62
H_20+	0.88	-	-	0.91	0.95	1.17	7.30	7.90	-	-
H_20-	1.95	-	-	2.56	3.35	3.98	-	-	-	-
H_2O_T	-	4.40	4.00	-	-	-	-	-	-	-
CO_2	17.35	27.60	29.50	13.76	16.25	16.03	5.40	10.80	-	-
S	-	0.12	0.10	-	-	-	-	-	-	-
LOI	31.59	30.50	31.70	29.15	27.85	27.13	-	-	10.00	6.30
Total	98.88	98.80	99.10	98.04	98.12	98.33	100.10	99.50	98.20	98.90
C.I	1.04	1.06	1.02	1.23	1.38	1.36	1.03	1.20	0.99	0.85
Si/Mg	0.78	0.79	0.75	0.86	0.96	0.98	0.79	0.88	0.73	0.63

LOI = loss on ignition; C.I = $(SiO_2+Al_2O_3+Na_2O)/(MgO+2K_2O)$ from Clement (1982); 1, 30 kimberlite pipes and dykes from Kimberley area, South Africa (Clement, 1982); 2, average of 623 analyses of Siberian kimberlites (Ilupin and Lutz, 1971); 3-4, massive macrocrystal hypabyssal kimberlites, Lac de Gras, Canada (Pell, 1997). * Data from A.R. Miller (pers. comm., 1996).

NOTE: bold headings denote carbonate-rich kimberlites; ** total Fe calculated as Fe_2O_3; all totals are quoted from referenced texts except samples from this work, in which totals are calculated on a CO_2, H_2O^+, and H_2O^- free basis.

Table 4.1. (continued).

wt. %	5	6	7	8	9	10	11	12	13
SiO_2	32.10	25.70	25.19	17.54	28.23	8.48	16.90	20.82	16.40
TiO_2	2.00	3.00	1.89	4.34	2.98	1.58	0.93	1.66	1.94
Cr_2O_3	-	-	-	-	-	-	-	-	-
Al_2O_3	2.60	3.10	2.87	5.01	1.22	1.5	0.79	0.10	1.28
Fe_2O_3	9.20**	12.70**	3.72	12.56	3.33	2.67	7.04	12.39	3.49
FeO	-	-	6.72	3.6	9.26	5.37	3.47	3.12	5.45
MnO	0.20	0.20	0.22	0.32	0.19	0.25	0.24	0.86	0.19
MgO	28.50	23.80	29.69	19.8	30.28	10.95	16.60	20.00	17.24
CaO	8.20	14.10	13.59	17.5	8.65	32.57	26.40	19.30	24.81
Na_2O	0.20	0.20	0.01	0.32	0.14	0.15	0.10	0.10	0.14
K_20	1.10	0.60	0.15	0.07	0.69	0.69	0.02	0.01	0.99
P_2O_5	1.10	1.10	2.2	5.11	0.42	1.76	1.36	0.68	1.80
H_20+	8.60	7.20	1.15	7.17	-	-	5.13	5.36	3.16
H_20-	1.10	0.50	-	0.87	-	-	0.28	0.01	-
H_2O_T	-	-	-	-	2.56	1.63	-	-	-
CO_2	4.30	8.60	12.83	6.33	11.28	29.97	19.23	14.64	23.39
S	-	-	-	-	-	-	-	-	-
LOI	-	-	-	-	-	-	-	-	-
Total	99.20	100.80	99.62	99.69	97.23	97.57	98.50	99.00	100.78
C.I	1.14	1.16	0.94	1.15	0.93	0.82	1.07	1.05	0.93
Si/Mg	0.87	0.84	0.66	0.69	0.72	0.60	0.79	0.81	0.74

5-6, on and off-craton south African kimberlites (Smith et al., 1985); 7, Benfontein sill composite sample (Dawson and Hawthorne, 1973); 8, Benfoentein fine grained aphyric sill (Dawson and Hawthorne, 1973); 9-10, single kimberlite dyke from West Greenland (Larsen and Rex, 1992): (9) olivine rich central portion; (10) carbonate-rich marginal portion ; 11-12 magnetite-serpentine-calcite dykes (Robinson, 1975); 13 carbonate rich kimberlite dyke, Holsteinsborg, Central West Greenland (Scott, 1979).

Table 4.1. (continued).

wt. %	14	15	16	17	18
SiO_2	31.80	29.94	30.50	14.32	15.62
TiO_2	2.09	1.47	1.56	1.51	1.41
Cr_2O_3	-	-	-	-	-
Al_2O_3	2.23	2.03	2.23	3.47	2.25
Fe_2O_3	8.25	6.50	6.70	4.05	2.22
FeO	3.63	3.46	3.20	1.85	1.81
MnO	0.16	0.14	0.16	0.24	0.44
MgO	32.40	30.04	29.89	7.66	7.13
CaO	3.25	6.27	6.86	35.18	37.27
Na_2O	0.05	0.05	0.13	0.05	0.05
K_20	1.45	1.26	1.17	0.74	0.86
P_2O_5	0.08	0.48	0.51	0.92	1.60
H_20+	-	-	-	-	-
H_20-	-	-	-	-	-
H_2O_T	10.57	10.70	10.35	1.74	2.64
CO_2	2.75	5.75	5.11	27.63	25.58
S	-	-	-	-	-
LOI	-	-	-	-	-
Total	99.05	98.40	98.75	99.64	99.54
C.I	0.97	0.98	1.02	1.95	2.02
Si/Mg	0.76	0.77	0.79	1.45	1.70

14-18 Koidu kimberlites, Koidu kimberlite complex, West African craton (Taylor et al.,1994): (14-16) hypabyssal dykes; (17-18) calcite-kimberlites.

Table 4.2. Compatible and incompatible trace element abundances for Meliadine kimberlites.

	Peter II	**Peter I***	**Peter II***	**K-L 2A-5**	**K-L 2A-7**	**K-L 2B-6**	IA	IB
V	181	190	190	143	162	119	75	170
Cr	357	-	240	445	478	424	1400	1000
Co	70	60	54	68	67	67	-	-
Ni	661	610	600	631	586	787	1360	800
Cu	86	63	83	53	69	51	-	-
Zn	60	62	54	54	66	51	-	-
Ba	859	732	750	1218	821	1188	1000	850
Rb	48	42	42	22	12	23	50	30
Sr	1195	1237	1265	1447	1482	1243	825	1020
Y	52	45	62	97	47	20	13	30
Zr	197	210	144	196	318	199	200	385
Nb	252	192	167	218	251	205	165	210
Hf	5	5	4	6	7	5	-	-
Ta	9	2	6	10	11	6	-	-
Th	258	310	220	40	26	61	18	27
U	16	25	15	6	5	5	4	6
Rb/Sr	0.04	0.03	0.03	0.02	0.01	0.02	0.06	0.03
Zr/Hf	37	40	34	34	44	44	-	-
Nb/Ta	30	96	30	23	24	32	-	-
Th/U	16	12	15	7	5	12	5	5

* Data from A.R. Miller (pers. comm., 1996); IA and IB, average trace element data for on-craton (IA) and off-craton (IB) south African kimberlites (Smith et al., 1985). Bolded headings denote carbonate-rich kimberlites; see Appendix II for errors associated with major and trace element data for Meliadine samples.

Table 4.2. (continued).

	1	2a	2b	3a	3b	4	5
V	100	140	192	496	247	170	75
Cr	893	1679	371	1467	816	1000	1400
Co	65	-	-	-	-	79	83
Ni	965	1056	53	663	329	800	1360
Cu	93	46	102	161	91	79	54
Zn	69	74	71	73	60	75	56
Ba	1100	723	4679	1309	2210	850	1000
Rb	73	42	38	95	53	30	50
Sr	851	956	1952	499	2524	1020	825
Y	22	10	34	15	25	30	13
Zr	184	201	393	179	412	385	200
Nb	141	163	311	-	-	210	165
Hf	6	-	-	-	-	-	-
Ta	11	-	-	-	-	-	-
Th	17	12	23	-	-	27	18
U	3	-	-	-	-	6	4
Rb/Sr	0.09	0.04	0.02	0.19	0.02	0.03	0.06
Zr/Hf	33	-	-	-	-	-	-
Nb/Ta	13	-	-	-	-	-	-
Th/U	5	-	-	-	-	4.5	4.5

1, average worldwide kimberlite (Mitchell, 1986); 2a-2b, West Greenland kimberlite dykes: (2a) olivine rich central portion; (2b) carbonate-rich part of same dyke (Larsen and Rex, 1992); 3a-3b, West Greenland kimberlite dykes (Scott, 1979); (3a) non-carbonate-rich dyke; (3b) evolved carbonate-rich dyke ; 4, average of 7 Group I on-craton southern African kimberlites (Smith et al., 1985); 5, average of 10 Group I off-craton southern African kimberlites (Smith et al., 1985).

Table 4.2. (continued).

	6	7a	7b	7c	7d	7e
V	91	58	45	61	71	78
Cr	1398	1490	1317	1340	1499	1711
Co	85	-	-	-	-	-
Ni	1018	1356	1301	1164	758	1288
Cu	52	-	-	-	-	-
Zn	63	70	60	53	104	74
Ba	915	1218	1787	2397	1879	1578
Rb	66	67	67	67	49	38
Sr	1145	420	708	707	1709	2621
Y	17	6	9	9	20	44
Zr	308	71	212	240	238	238
Nb	168	260	251	252	309	304
Hf	-	2.9	7	8.2	7.8	6.3
Ta	-	22.3	17.5	20	16.1	16.5
Th	-	41.9	37.5	22.3	31.6	20
U	-	4	4.6	3.4	8	4.7
Rb/Sr	0.06	0.16	0.09	0.09	0.03	0.01
Zr/Hf	-	24	30	29	31	38
Nb/Ta	-	12	14	13	19	18
Th/U	-	10	8	7	4	4

6, average of 30 kimberlite pipes Kimberly, South Africa (Clement, 1982); 7a-7e Koidu kimberlites, Koidu kimberlite complex, west African craton (Taylor et al., 1994): (7a-7c) hypabyssal dykes; (7d-7e) calcite-kimberlites.

Table 4.3. Rare earth element abundances for Meliadine kimberlite dykes and various other occurrences (ppm).

	Peter II	**Peter I***	**Peter II***	**K-L 2A-5**	**K-L 2A-7**	**K-L 2B-6**	world	1	2	3	**4**	**5**
La	151	160	150	169	167	116	150	219	207	227	227	149
Ce	253	240	210	293	307	194	200	444	430	493	416	281
Pr	22	29	25	26	27	17	22	-	-	-	-	-
Nd	78	90	78	96	98	59	85	137	161	190	143	107
Sm	13	14	12	15	16	9	13	14.6	18.5	20.6	20.5	16.5
Eu	3.4	3.5	3.3	4.1	4.1	2.6	3.0	2.88	4.12	4.65	5.06	4.26
Gd	10.4	9.4	10.0	13.2	12.3	7.4	8.0	-	-	-	-	-
Tb	1.3	1.1	1.4	1.5	1.2	0.8	1.0	0.75	0.85	0.84	1.15	1.07
Dy	6.9	5.5	7.4	8.2	5.5	3.5	-	-	-	-	-	-
Ho	1.7	1.3	1.9	1.9	1.0	0.7	0.6	0.42	0.54	0.56	0.72	1
Er	8.7	5.8	8.4	6.6	3.4	2.6	1.5	-	-	-	-	-
Tm	1.8	1.6	2.2	0.8	0.4	0.4	0.2	-	-	-	-	-
Yb	14.3	13.0	17.0	4.4	1.8	2.7	1.2	0.61	0.7	0.63	1.11	2.01
Lu	2.4	2.2	2.8	0.6	0.3	0.4	0.2	0.07	0.07	0.09	0.11	0.28
REE_T	566	576	529	640	645	416	486	819	823	937	815	562
$LREE_T$	516	533	475	599	615	395	470	815	817	931	807	554
$HREE_T$	47	40	51	37	26	18	13	2	2	2	3	4
$(La/Yb)_N$	6	7	5	22	53	24	70	201	166	202	115	42
$(La/Sm)_N$	6	6	6	6	6	6	6	8	6	6	6	5
$(Gd/Lu)_N$	1	1	0	3	5	2	6	-	-	-	-	-

LREE (La to Sm); HREE (Gd to Lu); N = chondrite normalized; T = sum (ppm).

Worldwide kimberlite data from Mitchell (1986); * Data from A.R. Miller (pers. comm., 1996).

1-5 Koidu kimberlites, Koidu kimberlite complex, West African craton (Taylor et al.,1994): (1-3) hypabyssal dykes; (4-5) calcite-kimberlites.

Headings in bold denote carbonate-rich kimberlites.

Table 4.4. Element concentrations** and measured isotopic ratios for Meliadine kimberlite dykes.

Sample	Rb ppm	Sr ppm	$^{87}Sr/^{86}Sr_{(0)}$	$^{87}Sr/^{86}Sr_{(T)}$	Sm ppm	Nd ppm	$^{143}Nd/^{144}Nd_{(0)}$	$^{143}Nd/^{144}Nd_{(T)}$	$^{Epsilon}Nd$
Peter II	47.68 [47.93]	1107.57 [1194.97]	0.705597 +/- 13*	0.70526	12.84 [12.79]	90.28 [77.62]	0.512613 +/- 7	0.512505	+2.2
K-L 2A-5	20.55 [21.92]	1435.17 [1447.06]	0.704123 +/- 17	0.70401	15.51 [15.11]	112.42 [96.13]	0.512688 +/- 10	0.512583	+3.8
K-L 2A-7	11.67 [12.84]	1654.19 [1482.13]	0.703734 +/- 19	0.70367	16.08 [15.52]	117.75 [97.71]	0.512739 +/- 9	0.512635	+4.8
K-L 2B-6	22.55 [23.44]	1271.32 [1242.66]	0.704470 +/- 13	0.70433	9.49 [9.32]	69.17 [58.73]	0.512759 +/- 7	0.512655	+5.2

CHUR present day: $^{143}Nd/^{144}Nd = 0.512638$ corrected for fractionation to $^{146}Nd/^{144}Nd = 0.7219$; $^{147}Sm/^{144}Nd = 0.2137$.

(T)= isotopic ratios corrected for an emplacement age of 192Ma; (0)= measured isotopic ratio.

$^{Epsilon}Nd = [(^{143}Nd/^{144}Nd)_T/(^{143}Nd/^{144}Nd)_{T\ CHUR} - 1] \times 10000$

* all errors are 2 sigma mean and reported on the sixth decimal place

** Concentrations in ppm obtained by isotope dilution; values in brackets obtained by ICP/MS.

CHAPTER 5

U-Pb GEOCHRONOLOGY

Introduction

Perovskite ($CaTiO_3$) and apatite [$Ca_5(PO_4)_3(OH, F, Cl)$] crystallize directly from the kimberlite magma to form groundmass minerals (Mitchell, 1986). These phases are the principle hosts for U and Th in kimberlites (Mitchell, 1989), and therefore have the potential to determine the age of emplacement using U-Pb geochronology.

Analytical Procedures

High purity perovskite and apatite concentrates were isolated by heavy liquid and hand picking techniques from the K-L 2B and K-L 2A/2B kimberlite dykes, respectively. Two perovskite fractions were selected and consisted of subhedral-to-euhedral grains of 25-50 µm. A third fraction consisting of apatite (euhedral columnar grains 45 x 20 µm) was also isolated in order to improve the U-Pb precision, and also to act as an independent constraint on the age, assuming all phases collected are primary and originated from the same magmatic event. U-Pb work was conducted at the University of Alberta U-Pb Geochronology Facility, with samples isolated by the author, and subsequent analytical work completed by Dr. Larry Heaman and laboratory staff (see Appendix III for details).

Results

Perovskite on average contains ~100 ppm U (range, 21-348 ppm), whereas apatite averages ~30 ppm with a range of 5-114 ppm (Heaman and Parrish, 1991). Uranium contents for Meliadine perovskites and apatites are lower than expected with average values of 87-98 ppm and 13 ppm, respectively (Table 5.1). In conjunction with low U, all samples contain appreciable common Pb. High common Pb in samples is directly correlated with correspondingly high uncertainties in U-Pb ages. This is evident in the Meliadine perovskite and apatite fractions in which $^{207}Pb/^{206}Pb$ model ages all have associated 2σ errors of ± 200 Ma (not listed in Table 5.1). For samples that are younger than 200 Ma it is more practical to report a $^{206}Pb/^{238}U$ age (Table 5.1) as it is least sensitive to the common Pb (Heaman and Parrish, 1991). Alternatively, a U-Pb isochron can be constructed where the results are not affected by the common Pb correction. Moreover, information pertaining to both age and the common Pb isotopic composition can be gathered from such a plot.

Table 5.1. U-Pb data for two K-L 2B perovskite fractions (P), and the single K-L 2A/2B apatite (A) fraction.

Sample	Weight (mg)	U (ppm)	Pb_T (ppm)	Pb_R (ppm)	Pb_C (%)	^{206}Pb/^{204}Pb (measured)	^{207}Pb/^{204}Pb (measured)	^{238}U/^{204}Pb (measured)	^{206}Pb/^{238}U (age Ma)
P-1	0.022	97.63	62.65	32.19	49	27.04 ± 0.078	16.08 ± 0.050	203.189 ± 1.374	272 ± 11
P-2	0.029	86.75	36.67	26.24	28	36.761 ± 0.518	16.519 ± 0.074	525.231 ± 15.108	223 ± 5
A-3	0.017	12.91	3.67	0.46	87	25.905 ± 0.562	16.002 ± 0.144	253.411 ± 17.258	191 ± 10

Estimated total blanks for Pb and U are 8pg and 2pg, respectively. The precision quoted for all initial isotopic ratios includes in-run measurement precision of 2σ, with reproducibility of standards, and the uncertainties in the parent/daughter ratios. Measured Pb isotopic ratios have been corrected for fractionation, blank, and spike. T = total; R = radiogenic; C = common.

A monomineralic U-Pb isochron diagram plotting measured ^{206}Pb/^{204}Pb against measured ^{238}U/^{204}Pb was constructed using perovskite (Fig. 5.1); the apatite fraction was excluded from the age calculation, but will be discussed later. The slope of this isochron corresponds to an Early Jurassic age of 192 ± 13 Ma (2σ error) with an initial ^{206}Pb/^{204}Pb lead isotopic composition of 20.91 ± 0.46. Initial ^{206}Pb/^{204}Pb lead isotopic compositions for Group I kimberlites in general range from 18.45-20.05 (Smith, 1983). K-L perovskites contain an initial ^{206}Pb/^{204}Pb lead isotopic composition of 20.91 ± 0.46 which is slightly higher than expected, but is still geologically reasonable. The reliability of the two fraction perovskite ^{206}Pb/^{238}U age is uncertain and should be treated as a best estimate for the age of emplacement. Confirmation of the age is required, preferably by obtaining more perovskite fractions, or further U-Pb and(or) Rb-Sr geochronology on suitable phases from other kimberlite bodies within the study area. Miller et al. (1998) obtained an Rb-Sr phlogopite age of 214.3 ± 1 Ma (L. Triassic) from the October kimberlite dyke (cf. Table 1.1), however, this age has must also be confirmed.

The apatite fraction was excluded from the ^{206}Pb/^{238}U age because it plots well below the 192 Ma isochron (Fig. 5.1). This is peculiar considering that if the perovskite and apatite crystallized from the same magma they should possess identical initial ^{206}Pb/^{204}Pb lead isotopic compositions. This however is not the case, and the actual initial ^{206}Pb/^{204}Pb isotopic composition for the apatite fraction is 18.26 assuming the 192 Ma perovskite age (Fig. 5.1b). Because the apatite fraction is considered to be a primary phase from the kimberlite and not inherited (i.e., xenocrystic) it may represent another pulse of kimberlite magmatism, therefore leading to the different initial $^{206}Pb/^{204}Pb$ isotopic composition relative to perovskite. Alternatively, the $^{206}Pb/^{204}Pb$ may have changed during the final stages of groundmass crystallization. A definitive answer to this discrepancy is lacking.

Age Interpretation

Dated kimberlites in Canada occur within three geologic eras; Paleozoic, Mesozoic, and Cenozoic (Table 5.2). The Archean Slave province kimberlites span the entire age range with intrusions occurring in the Cambrian, Late Ordovician, Late Jurassic, Late Cretaceous, and Eocene (Heaman et al., 1997; Kjarsgaard, 1996b and references therein; Carlson et al., 1998 and references therein). The remaining intrusions are all restricted to the Mesozoic: the Late Cretaceous Somerset Island kimberlites (Kjarsgaard, 1996c and references therein); Cretaceous Saskatchewan kimberlites (Kjarsgaard, 1996d and references therein); Late Jurassic Kirkland Lake and Lake Timiskaming kimberlites (Schulze, 1996 and references therein); Cretaceous Buffalo Hills kimberlites (Carlson et al., 1998); and the Triassic Crossing Creek kimberlite (Smith et al., 1988).

The Meliadine dykes represent the first Early Jurassic (192 ± 13 Ma) kimberlites within the Archean Churchill Province. Given that the age is of uncertain reliability and is at best an estimate for the age of emplacement, a detailed discussion and interpretation of the age is unjustifiable.

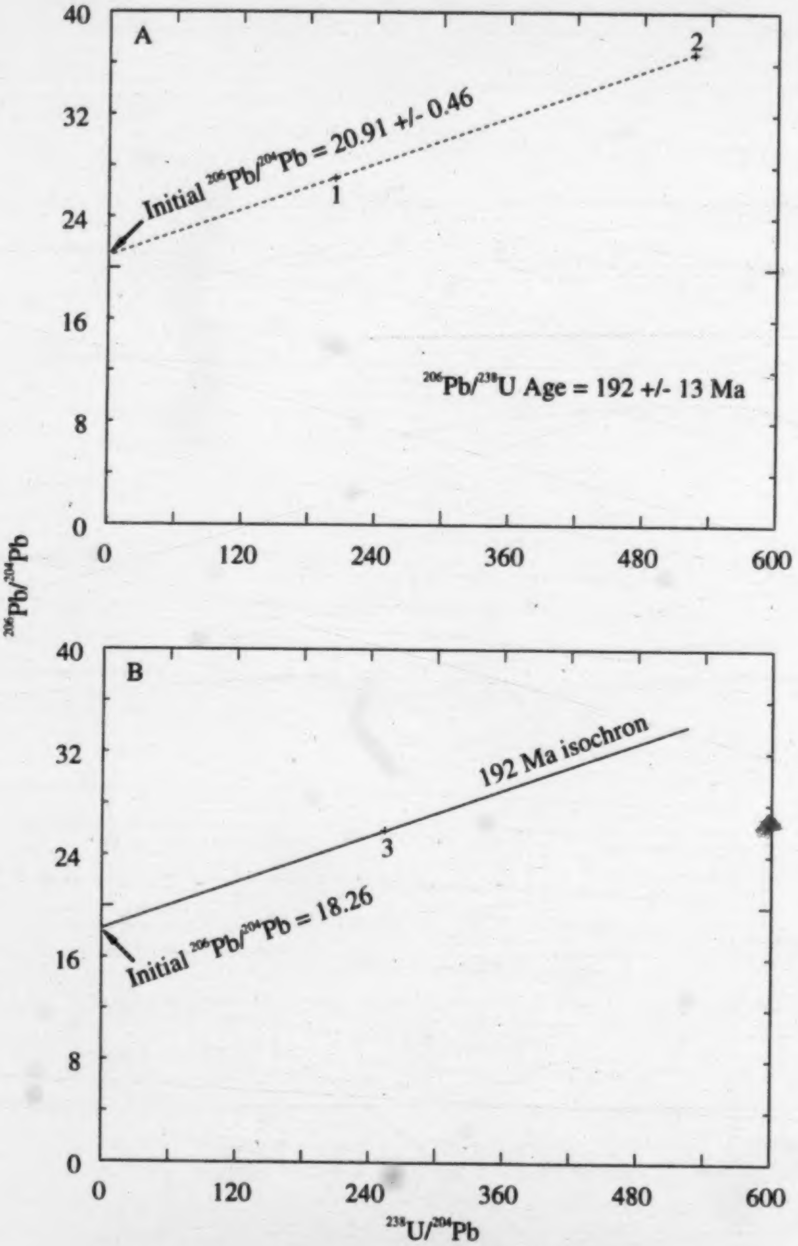


Fig. 5.1. U-Pb isochron diagram for perovskite fractions from K-L 2A (A), and a single combined apatite fraction from K-L 2A and K-L 2B (B). Fractions identified by numbers corresponding to numbering system in Table 5.1.

Table 5.2. Emplacement ages for dated Canadian kimberlites (data sources from text).

AGE OF KIMBERLITE MAGMATISM (Era-Period)	OCCURRENCE AND DATING METHOD
	Slave Province, NWT
47.5 ± 0.5 Ma *(Cenozoic-Tertiary)*	KIA93-K136 (Rb-Sr phlogopite)
74 ± 3 Ma *(Cenozoic-Cretaceous)*	C-13 pipe (U-Pb perovskite)
172 ± 2 Ma *(Mesozoic-Jurassic)*	Jericho (Rb-Sr phlogopite)
538.6 ± 2.5 Ma *(Paleozoic-Cambrian)*	5034-Kennedy Lake (Rb-Sr phlogopite)
437-447 Ma *(Paleozoic-Siluro/Ordovician)*	Dry Bones (U-Pb mantle zircon)
480 Ma *(Paleozoic-Ordovician)*	
	Somerset Island, NWT
88 Ma *(Mesozoic-Cretaceous)*	Ham kimberlite (U-Pb perovskite)
105 Ma *(Mesozoic-Cretaceous)*	Georgia (U-Pb perovskite)
100 Ma *(Mesozoic-Cretaceous)*	Tunraq (Rb-Sr phlogopite)
241 ± 5 Ma *(Mesozoic-Triassic)*	**Crossing Creek, British Columbia**
	(Rb-Sr phlogopite/whole rock)
86 ± 3 Ma and 88 ± 5 Ma *(Mesozoic-Cretaceous)*	**Buffalo Hills, Alberta**
	(U-Pb perovskite)
	Prairie Kimberlites, Saskatchewan
98 ± 1 Ma *(Mesozoic-Cretaceous)*	SL2 kimberlite (Rb-Sr phlogopite/whole rock)
98.5 Ma *(Mesozoic-Cretaceous)*	Fort à la Corne pipes (Local Stratigraphy)
155-159 Ma *(Mesozoic-Jurassic)*	**Kirkland Lake and Lake Timiskaming, Ontario**
	(U-Pb perovskite)
	Melladine Dykes, NWT
192 ± 13 Ma *(Early Jurassic)*	(U-Pb perovskite)

CHAPTER 6

AN ULTRAPOTASSIC DYKE FROM THE MELIADINE PROPERTY: INTRODUCTION

An ultrapotassic (molar $K_2O/Na_2O > 3$) dyke (Aya) was intersected in diamond drill hole ML96-136 on the Meliadine property. The dyke was encountered at the 102.54 to 103.75 m level (1.21 m apparent width), approximately 7 m below K-L 2D, the last kimberlite intersection in ML96-136 (cf. Table 1.1). Aya may be correlated with the extensive Early Proterozoic ultrapotassic rocks of the Christopher Island Formation (CIF), that lie ~ 400 km to the west of the Meliadine property, within the Baker Lake Group, Churchill Province, Canada.

The CIF are non-marine potassic to ultrapotassic dykes, lava flows, and pyroclastics located within the Baker Lake Group of the Early Proterozoic Dubawnt Supergroup. Compositionally, CIF rocks range from mafic lamprophyres consisting of phlogopite phenocrysts + diopside + apatite ± olivine ± magnetite, to phenocryst-poor felsic rocks and sanadine porphyries (Peterson, 1991). The Baker Lake Group is a 400 km long system of ENE-trending basins ranging in size from 25 to 150 km long (Peterson, 1991). The basin itself (Baker Lake Basin, Fig. 6.1) is surrounded by a swarm of alkaline, ultrapotassic lamprophyre dykes that crop out over an area of 100,000 km^2, which may outline the general shape and possible extent of the region within the central Keewatin underlain by an enriched upper mantle (LeCheminant et al., 1987).

Geochemically and petrographically, CIF rocks are transitional from minette to lamproite with an overall character similar to that of young Mediterranean lamproites, with such occurrences as Spain, Corsica, and northern Italy (Peterson et al., 1994). The geology, tectonic environment, mineralogy, and geochemistry of the CIF rocks are discussed in LeCheminant et al. (1987), Peterson and Rainbird (1990), Peterson (1991), and Peterson et al. (1994).

These authors proposed that the potassic to ultrapotassic rocks of the CIF resulted from subduction of oceanic lithosphere that was underplating the central Churchill during the ~ 2.0 Ga Slave and ~ 1.9 Ga Superior collisions. Their proposed model invokes subduction related metasomatic fluids and near-solidus melts derived from the slabs that metasomatised the overlying convecting lherzolitic mantle, resulting in a phlogopite-bearing enriched mantle assemblage. This region subsequently melted, and these melts interacted with the overlying depleted, harzburgitic lithospheric mantle to produced the CIF magmas (Peterson et al., 1994). Magmas derived from the metasomatised lherzolitic mantle were dominantly minette in character, whereas interaction of these magmas with the overlying depleted harzburgitic lithosphere produced magmas lamproitic in nature (Peterson et al., 1994).

This chapter presents the petrography, mineral chemistry, and isotope geochemistry of the Aya dyke in order to address the relationship of this dyke to the CIF.

PETROGRAPHY AND MINERAL CHEMISTRY

Core samples of the dyke are melanocratic with pale light-green ovoid phenocrysts of amphibole set in a fine grained matrix consisting of brown mica plus interstitial carbonate. Phenocrysts typically are 2.0 x 1.0 mm and may show a crude lineation. Matrix micas may also show a weak lineation in regions. Carbonate veining (≤ mm widths) occurs throughout the dyke with intensity varying from sparse to locally abundant.

Petrographically, the dyke contains 45-55 modal % phlogopite, 30-35 % amphibole, ≤ 1 % apatite, 5-10 % carbonate, and trace opaques. Texturally, the dyke contains glomeroporphyritic clusters of amphibole blades tangentially surrounded by mica laths (Fig. 6.2). These glomeroporphyritic features are termed globular structures, and are found commonly in all lamprophyre types (calc-alkaline, alkaline, and ultramafic), and occur less frequently in basalts (Rock, 1986). The term globular structure is non-genetic and used to describe irregular, drop-like, subrounded or circular, leucocratic to hololeucocratic bodies surrounded by tangential biotite or hornblende within mafic host rocks (Rock, 1991). The mineral compositions of such structures varies, and can contain feldspars, feldspathoids, quartz, amphibole, pyroxene, biotite, epidote, scapolite, and carbonate (cf. Table 1 Rock, 1986). Globular structures observed in Aya appear either as closed structures sharply defined by tangential mica, or as less well-defined 'open' segregations grading into the surrounding host.

With increasing amounts of carbonate veining, the mineralogy of the dyke changes, with the addition of fine grained subhedral quartz, anhedral patches of Na-rich plagioclase (dominantly associated with carbonate vein margins), an increase in modal apatite, a decrease in phlogopite, as well as a decrease in the number of globular structures present.

Phlogopite

Phlogopite, which modally dominates the dyke, occurs as subhedral plates and laths that tangentially surround globular structures, and make up the matrix of the dyke. Laths may show slight kinking, however, bent laths are more common. Inclusions may occur within the grains and consist of the following (±): extremely fine grained slender rutile needles (0.15 x 0.0016 mm) oriented in three directions to give a triangular pattern (confirmation as rutile was not possible because of fine grain size); apatite; opaques; and Ca-Mg-Fe carbonate ribbons (Fig. 6.2B). Chlorite alteration along grain margins and cores is rare, and is generally restricted to regions that have experienced more intense carbonate veining. Rare illitization of cores was also observed. Normal pleochroism is exhibited by all grains with colours varying from colourless/pale yellow to pale brown/reddish brown. No optical zonation of grains was observed.

The compositions for Aya micas are plotted in Al_2O_3 versus TiO_2 and FeO_T diagrams (Figures 6.3 and 6.4), with representative compositions listed in Table 6.1. Compositionally, Aya phlogopite is relatively homogeneous, except for a general core to rim decrease in Cr-content, however, this is not always observed (Table 6.1). Geochemically, grains are Al-rich and Ti-poor relative to mica from orangeites, and lamproites, but compositionally similar to the least evolved kimberlite microphenocryst micas (Fig. 6.3A), and similar to mica from minette lavas of the Roman Province (Fig. 6.3B). Figure 6.4 illustrates a distinct evolutionary trend in which Fe increases with relatively constant Al-contents. This evolutionary trend begins with relatively unevolved high MgO, low FeO micas (Table 6.1, anal. 1-5), to progressively FeO-rich and MgO-poor varieties relative to unevolved micas (Table 6.1, anal. B to J to D to F, Fig. 6.5), of which, all examples display relatively constant Al and Ti-contents. This evolutionary trend is also seen in mica from Roman Province minette lavas (Fig. 6.4B), and typical of minette micas in general (Mitchell and Bergman, 1991).

Amphibole

Amphibole occurs almost exclusively within the globular structures previously described, as fan-like clusters or as groups of bladed grains aligned in various orientations. The structures are composed of amphibole with minor to trace amounts of ± carbonate, ± opaques, ± apatite, ± phlogopite, and are generally wholly enclosed by and separated from one another by phlogopite. Amphibole is non-pleochroic, and chemically (Table 6.2) is classified as actinolite, a member of the calcic-amphibole series (Leake et al., 1997). Aya amphiboles have variable mg# (76.67-92.80), K/(K+Na) [0.17-0.65], and Ca>Na+K.

Calcic-amphiboles similar to those present in Aya occur in all lamprophyres (calc-alkaline, alkaline, and ultramafic), but tremolite-actinolite is generally considered to represent a secondary phase within these rocks (Rock, 1991). The secondary nature of the amphibole is likely a result of autometasomatic alteration of a primary ferromagnesian mineral phase (i.e., diopside) resulting from the high volatile content of lamprophyres (Rock, 1991). Amphiboles also occur in lamproites and orangeites. In these rocks they are characteristically titanian potassium richterite and titanian potassium magnesio-kataphotite, and potassium richterite, respectively (Mitchell and Bergman, 1991; Mitchell, 1995b).

Apatite, Carbonate, Opaques

Apatite occurs commonly as subhedral inclusions in phlogopite and within the matrix with an average size of 0.1 x 0.06 mm. Analysis from Table 6.3 indicate that Aya apatites are compositionally fluor-apatites (2.73-3.48 wt.% F) with minor amounts of strontium (1.28-1.88 wt.%); some samples (Table 6.3, anal. 3-4) have minor amounts of silica replacing phosphorous. Trace LREE enriched apatites were also observed. Semi-quantitative EDS analysis by electron microprobe showed enrichments in La_2O_3 (9.10 wt. %), Ce_2O_3 (23.26 wt. %), and Eu_2O_3 (2.28 wt. %), and high SO_3 (6.30 wt. %) relative to the majority of apatites analysed. Compositionally, Aya apatite is similar to apatite from lamproites, which are fluor-apatites (2-7 wt. %) characterized by high SrO (> 1 wt. %), and generally low silica (typically < 1 wt. %) [Mitchell, 1995b].

Carbonate occurs as a groundmass phase and also as secondary veining. Groundmass carbonate occurs as interstitial patches to matrix material, and is dominantly $CaCO_3$. Veins are $CaCO_3$ with blebs of Ca-Mg-Fe carbonate commonly located within vein centres. Ribbons of Ca-Mg-Fe carbonate are also found within phlogopite (appear as inclusions).

Opaques occur in trace amounts in all analysed samples of the dyke, and are euhedral-to-subhedral in habit. Opaques include pyrite, arsenopyrite, and Fe-Co-Ni-As-S sulphides (i.e., gersdorfite [NiAsS]).

Rb-Sr PHLOGOPITE/WHOLE ROCK GEOCHRONOLOGY

A Rb-Sr whole rock isochron age of 1792 ± 32 Ma was obtained for the Aya dyke. Initially, two acid leached phlogopite separates from Aya1 (Table 6.4, see Appendix III for details) were dated by Rb-Sr, and yielded ages of 1691 Ma (phl1) and 801 Ma (phl2) assuming initial Sr of 0.70500. It was assumed that the phlogopite separates need a primary origin, and ages derived from these samples would represent the age of emplacement. Phl2 has a substantially lower age relative to phl1 (regardless of initial Sr used), and as a consequence, these grains likely acted as an open system with respect to Rb and Sr, which would lead to a loss of radiogenic Sr thereby causing the younger age. Because closed system behavior was not maintained, the Rb-Sr age is spurious. With similar reasoning applied to phl1, the 1691 Ma age is at best a minimum, and must be treated with caution. Open system behavior may have occurred, thus resulting in a lower age.

To overcome the uncertainties associated with the phlogopite ages, a two point whole rock Rb-Sr isochron age was determined for Aya. An age of 1792 ± 32 Ma with initial $^{87}Sr/^{86}Sr$ of 0.70400 was obtained with errors calculated from analytical uncertainties. The age of emplacement is therefore suggested to be 1792 ± 32 Ma, however, with the caveat that the age was determined by a two point isochron, and there is no independent constraint on the reliability of the analysis.

The 1792 ± 32 Ma ultrapotassic Aya dyke may be correlated with the ca. 1.84 Ga Christopher Island Formation ultrapotassic rocks situated within the Keewatin hinterland. Available age data for the ultrapotassic magmatism of the CIF is based on relatively few age dates. Tella et al. (1985) obtained a U-Pb zircon age of 1850 +30/-10 Ma for a quartz syenite body related to the CIF. Loveridge et al. (1987) obtained a 1743 +3/-2 Ma U-Pb zircon age for a well established cross-cutting intrusion, which constrains the lower age limit for CIF magmatism. Finally, a genetically related plutonic suite from the Dubawnt Lake area yielded a $^{40}Ar/^{39}Ar$ hornblende age of 1825 ± 12 Ma (Roddick and Miller, 1994). The Rb-Sr whole rock isochron age of 1792 ± 32 Ma for Aya therefore correlates with CIF magmatism.

MAJOR, TRACE ELEMENT AND ISOTOPIC GEOCHEMISTRY

The geochemistry of the Aya dyke is based on two whole-rock samples. Aya1 is considered to represent the most "pristine" of the samples because secondary carbonate veining in this sample is macroscopically and microscopically sparse to absent. Aya2 displays prominent veining (> 5 modal %) [see Appendix II for analytical details].

Major Elements

Major element and selected trace element geochemistry for Aya are shown in Tables 6.5 and 6.6. Aya has been classified using multielement discriminant diagrams of Foley et al. (1987), Sahama (1974), and Barton (1979) [Fig. 6.6]. Sahama (1974) classified potassic alkaline rocks as being either kamafugites or orendites (a term synonymous with lamproite) based mainly on SiO_2 and CaO contents, and on modal mineralogy, which directly reflects the silica activity in these rocks (Fig. 6.6A). Kamafugites are characterized by kalsilite and melilite, whereas orendites are distinguished by the presence of sanadine, with leucite common to both. Barton (1979) proposed a threefold (composition, mineralogy, and petrography) system for classifying potassium-rich rocks, one in which Leucite Hills type lavas (LHT), Roman province type lavas (RPT), and Toro-Ankole type lavas (TAT) are defined (Fig. 6.6B). Mineralogically, LHT lavas contain Al-poor pyroxene, micas, and amphibole, in conjunction with priderite and wadeite (alkali-bearing accessory phases), and ferric Fe-rich leucite and sanadine; RPT lavas commonly contain Al-rich pyroxenes, Fe-poor leucite, and sanadine with plagioclase; TAT lavas contain silica-deficient or stoichiometric leucite with kalsilite, melilite, and perovskite. Foley et al. (1987) attempted to classify ultrapotassic rocks based solely on major element screens $K_2O > 3$ wt.%, $MgO > 3$ wt.%, and $K_2O/Na_2O > 2$ for whole-rock analyses, along with multi-element variation discriminant diagrams (Fig. 6.6C, D). Foley et al. (1987) subdivided ultrapotassic rocks into three groups: Group I rocks (low Al_2O_3, CaO, Na_2O, variable TiO_2) are lamproites with West Kimberly and Gaussberg as the standard members; Group II rocks (low Al_2O_3, Na_2O, high CaO, and low SiO_2 [< 45wt.%]) are kamafugites with Toro-Ankole as the standard member; and Group III ultrapotassic rocks (high Al_2O_3, low TiO_2) are Roman Province Type lavas or plagioleucitites (Foley, 1992). In all three geochemical classification schemes, Aya displays selected major element criteria for kamafugites or Group II ultrapotassic rocks, but differs mineralogically.

Trace Elements

Abundances of Ni (602 ppm) and Cr (1451 ppm) in Aya1 are high, consistent with a mantle origin (Table 6.6). Aya is enriched in large-ion lithophile elements (LILE), Th, Ba, and REE relative to common mantle-derived magmas, such as MORB and OIB. Incompatible trace element data for Aya (Table 6.6) are plotted in primitive mantle-normalized trace element variation diagrams (Fig. 6.7) [normalizing values from Sun and McDonough, 1989]. Negative anomalies occur for Rb, Nb, Ta, Ti, and Sr, and positive anomalies for Th, La, and Ce are present. The overall pattern is similar to that of CIF ultrapotassic lavas (Fig. 6.7B) and Keewatin lamprophyre dykes. Differences in the patterns include extreme enrichment in Th and Tb through to Yb, greater depletion in Sr (Aya1 only), and lack of a positive Zr anomaly, for Aya relative to CIF. The significant depletions in Nb, Ta, and Ti are similar to those observed in potassic lavas from the Roman province, Italy (Fig. 6.7C), which are associated with plate convergence. The cause for Th and HREE anomalies is unknown, while the Sr anomaly may be linked with the absence of clinopyroxene in the source region (Mitchell, 1995b).

Rare earth element data for Aya is listed in Table 6.6, with data plotted in Figure 6.8. Relative to CIF rocks, Aya is richer in all REE, specifically HREE. Compared to other alkaline rocks (Fig. 6.10B) Aya displays similar LREE abundances to lamproites and kimberlites, and extreme enrichment in HREE [$(La/Yb)_N$= 5-6] relative to: lamproites ($[La/Yb]_N$= 130); kimberlites ($[La/Yb]_N$= 84); ultramafic lamprophyres ($[La/Yb]_N$= 44); alkaline lamprophyres ($[La/Yb]_N$= 25); and calc-alkaline lamprophyres ($[La/Yb]_N$= 17).

The enrichment in HREE in the Aya dyke is similar to that observed in the Meliadine kimberlite dykes (cf. Fig. 4.2). A connection between the two occurrences based on REE profiles, specifically HREE enrichment might suggest that similar source regions were involved in the genesis of these rocks. This however is an implausible scenario, as isotopic data reveal distinctly different source regions for Meliadine kimberlites (cf. Fig. 4.5) compared to the Aya dyke (discussed below; cf. Fig. 6.9).

Strontium ($^{87}Sr/^{86}Sr$) and Neodymium ($^{143}Nd/^{144}Nd$) Isotopes

Sr and Nd whole-rock data for Aya are summarized in Table 6.6 and $\varepsilon_{Nd(1792\ Ma)}$ versus initial $^{87}Sr/^{86}Sr$ plotted in Fig. 6.9. Initial $^{87}Sr/^{86}Sr$ for Aya is relatively non-radiogenic (0.70400) near bulk Earth, with low non-radiogenic $\varepsilon_{Nd(1792\ Ma)}$ of –8.8. These isotopic characteristics are similar to CIF rocks (average initial $^{87}Sr/^{86}Sr$ of 0.70407, and average $\varepsilon_{Nd(1840\ Ma)}$ of –7.4), and Keewatin lamprophyres (average initial $^{87}Sr/^{86}Sr$ of 0.70247, and average $\varepsilon_{Nd(1840\ Ma)}$ of –8.4). These magmas exhibit old LREE-enriched (low Sm/Nd) source regions depleted in Rb (low Rb/Sr). Isotopic characteristics such as these are common for ultrapotassic rocks of North America (e.g., Leucite Hills, Smoky Butte, and N.W Colorado), suggesting a common tectonic factor and source region (Peterson, 1991 and references therein). Depletion of Rb in the source region, required by the low Rb/Sr may be linked to episodes of melt extraction(s) (basaltic ?) during the early Archean, consistent as well with the depleted mantle Nd model ages of approximately 2.8 Ga for Aya and CIF rocks (Peterson, 1991). Comparable rocks displaying relatively non-radiogenic initial $^{87}Sr/^{86}Sr$ and negative ε_{Nd} occur in N.W Colorado, Smoky Butte, and Leucite Hills, all of which were probably derived from an ancient, isolated, metasomatised subcontinental lithospheric source having long-term low Rb/Sr and Sm/Nd (Nelson, 1992). Such sources are considered to have originally been relatively depleted (depleted lherzolite or harzburgite), with the later introduction of incompatible element-rich components (solids, melts or hydrous fluids) derived from subducted oceanic crust (Nelson, 1992). Such a process readily explains the observed isotopic characteristics and trace incompatible element abundances displayed by Aya, CIF ultrapotassic rocks, and other North American potassic rocks. A more detailed discussion on the involvement and evidence for subducted sediments in the genesis of potassic igneous rocks is given in Nelson (1992).

CLASSIFICATION OF AYA

On the basis of major element geochemistry, Aya can be classified as kamafugitic (Sahama, 1974; Barton, 1979; Foley et al., 1987; Foley, 1992a). This classification is untenable, however, because Aya does not have the request mineralogy of kamafugitic rocks. Major element data for Aya more closely approximate ultramafic lamprophyres (cf. Rock, 1986): low SiO_2 (mean 25-35 %), high Al_2O_3 (mean 4-11 %), and high CaO (mean 12-20 %), in conjunction with the presence of phlogopite + amphibole, and the absence of melilite, feldspathoids, and alkali feldspar. More specifically, the aforementioned criteria semi-quantitatively classify (Rock, 1986) the Aya ultrapotassic dyke as an ultramafic lamprophyre. This is also confirmed by using the flow chart classification scheme from Woolley et al. (1996), in which Aya falls within the lamprophyre clan. Isotopic and trace element geochemical data are consistent with, and similar to CIF lavas, albeit mineralogically Aya is slightly different. Aya therefore represents a spatially disparate, previously undescribed 1792 ± 32 Ma ultrapotassic member of the CIF.

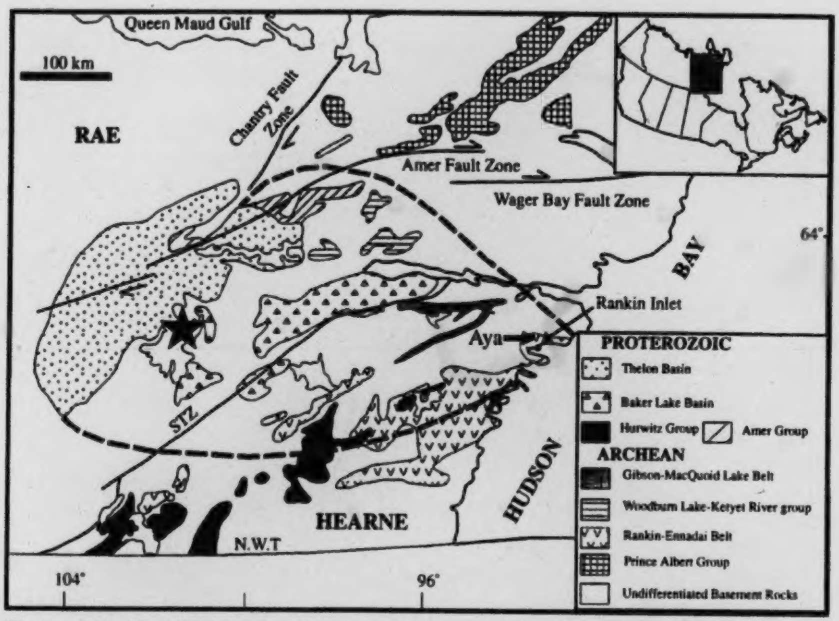
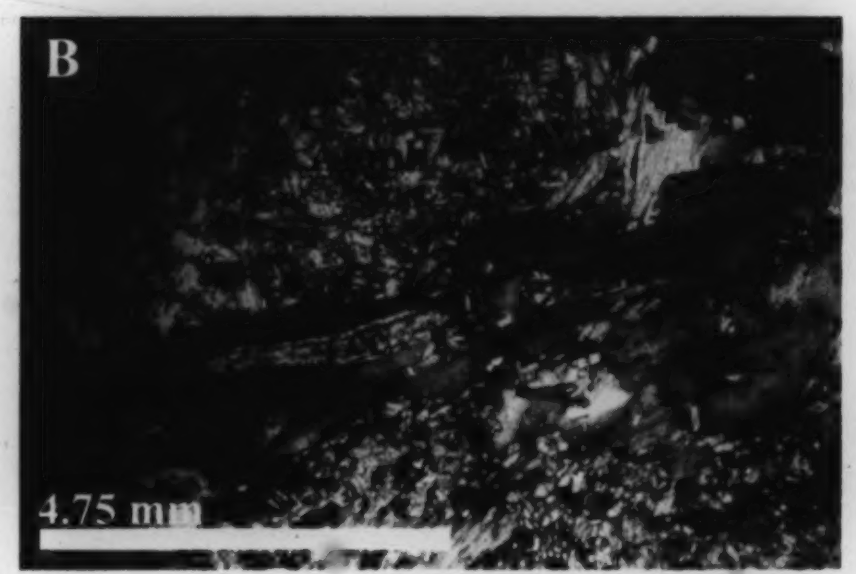

Queen Maud Gulf
100 km
RAE
Chantry Fault Zone
Amer Fault Zone
Wager Bay Fault Zone
64°
BAY
Rankin Inlet
Aya
STZ
HEARNE
HUDSON
N.W.T
104°
96°
PROTEROZOIC
Thelon Basin
Baker Lake Basin
Hurwitz Group
Amer Group
ARCHEAN
Gibson-MacQuoid Lake Belt
Woodburn Lake-Ketyet River group
Rankin-Ennadai Belt
Prince Albert Group
Undifferentiated Basement Rocks

Figure 6.1. Simplified regional map of the central Churchill Province displaying the approximate outer limits (dashed line) of ultrapotassic lamprophyre dykes (from LeCheminant et al., 1987), [map modified after MacRae et al., 1995]. Aya is located north of Rankin Inlet, and CIF rocks from Peterson et al. (1994) are designated by the star.

Figure 6.2. Aya ultrapotassic dyke (A, B). Texturally, the dyke consists of glomeroporphyritic clusters of amphibole (Amph.) tangentially surrounded by phlogopite (M). Inclusions of carbonate ribbons (cc) consisting of Ca-Mg-Fe carbonate may occur in phlogopite grains.

A
M
1.2 mm


B
4.75 mm

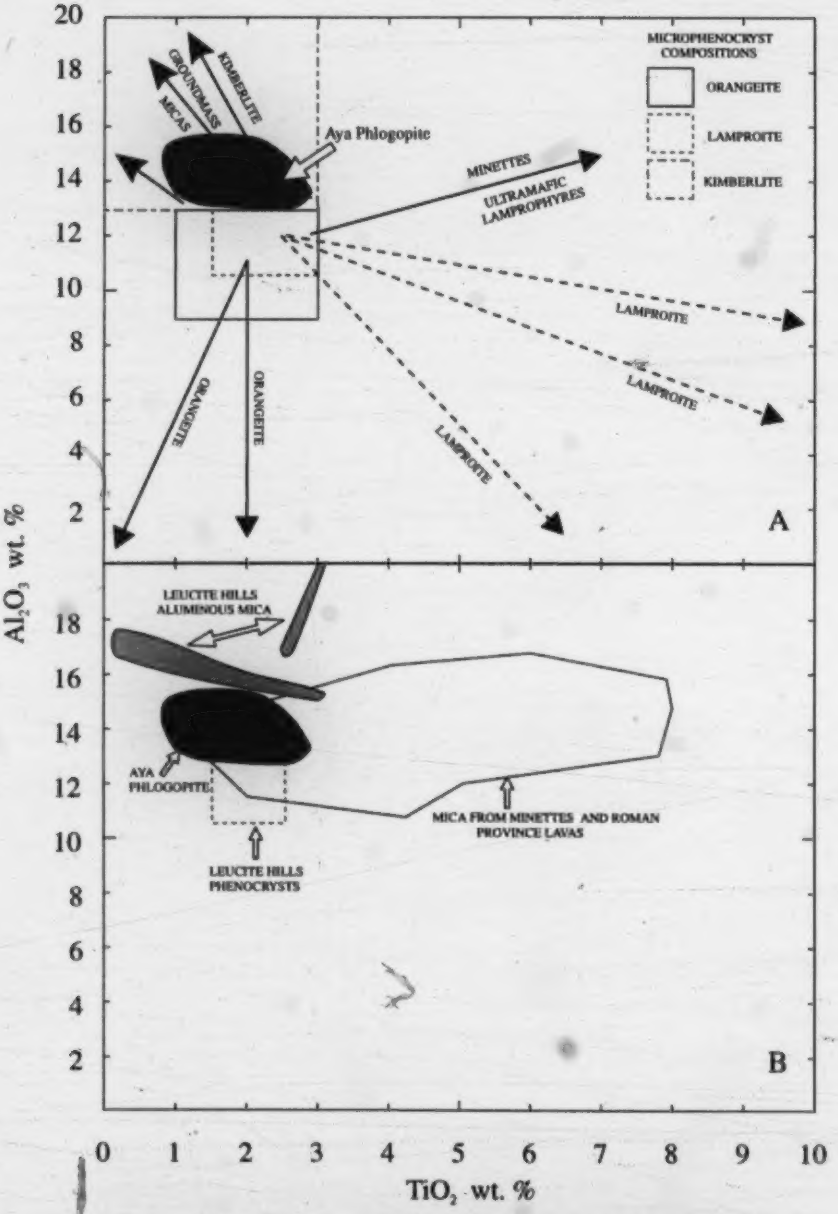


Figure 6.3. Al_2O_3 versus TiO_2 compositional variation and mica evolutionary trends of mica from Aya, kimberlites, orangeites, lamproites, and minettes/ultramafic lamprophyres (A) [modified from Mitchell 1995b], and compositional variation for mica from minettes and lamproites (B) [from Mitchell and Bergman 1991].

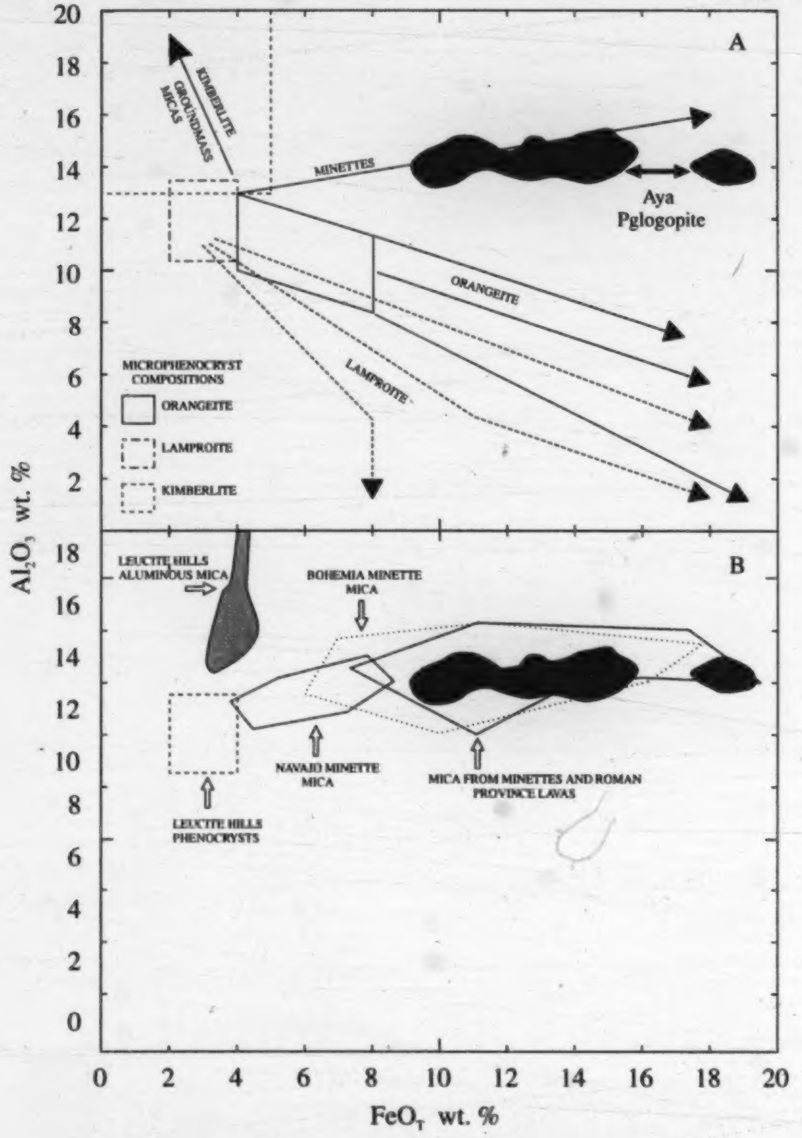


Figure 6.4. Al_2O_3 versus FeO_T compositional variation and mica evolutionary trends of mica from kimberlites, orangeites, lamproites, minettes, and Aya (A) [modified from Mitchell, 1995b], and compositional variation of mica from minettes, lamproites, and Aya (B) [from Mitchell and Bergman, 1991].

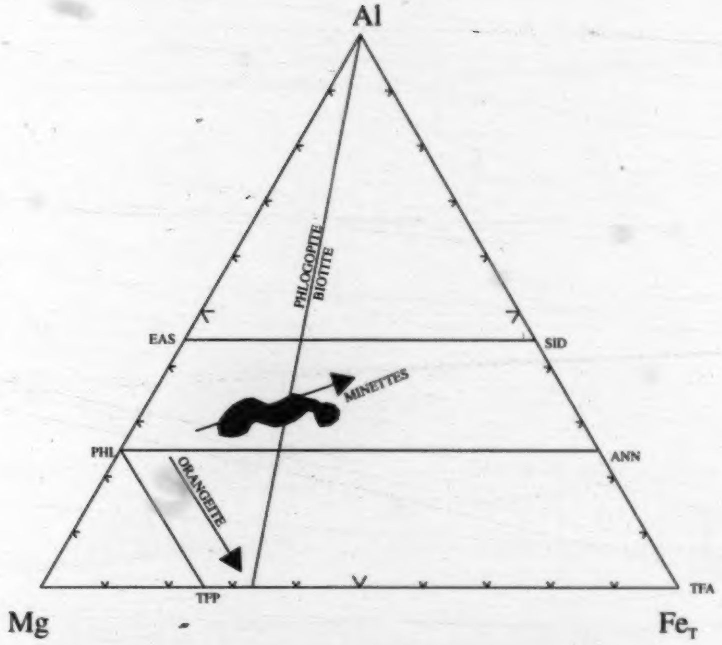


Figure 6.5. Compositional trends (atoms/11 oxygen) for micas from minettes and orangeites along with Aya phlogopites plotted in the Al-Mg-Fe$_T$ (atomic) system. Total Fe expressed as Fe$_T$. EAS = eastonite, SID = siderophyllite, PHL = phlogopite, ANN = annite, TFP = tetraferriphlogopite, and TFA = tetraferriannite.

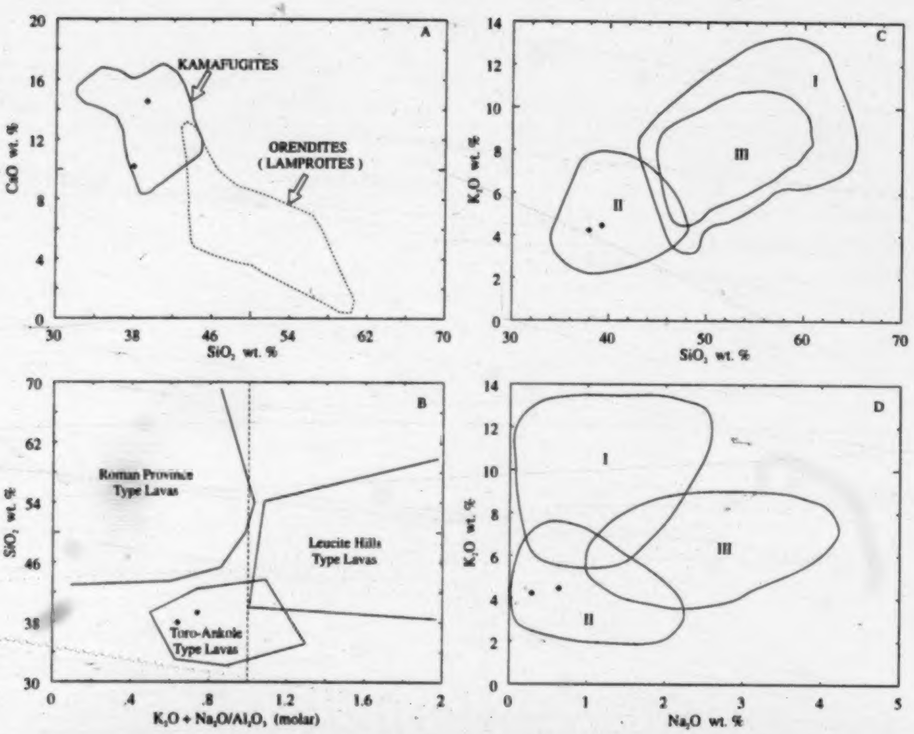


Figure 6.6. Mulitielement major element plots for the Aya ultrapotassic dyke: (A) CaO versus SiO_2 plot for Aya with relative to fields for Kamafugites and Orendites (lamproites) [from Sahama 1974]; (B) SiO_2 versus peralkalinity index for Aya with relative fields for Roman Province type lavas (RPT), Leucite Hills type lavas (LHT), and Toro-Ankole type lavas (TAT) [from Barton 1979]; K_2O versus SiO_2 (C) and Na_2O (D) for Aya relative to ultrapotassic rock groups I (lamproites), II (kamafugites), and III (plageoleucitites) [Foley, 1992a].

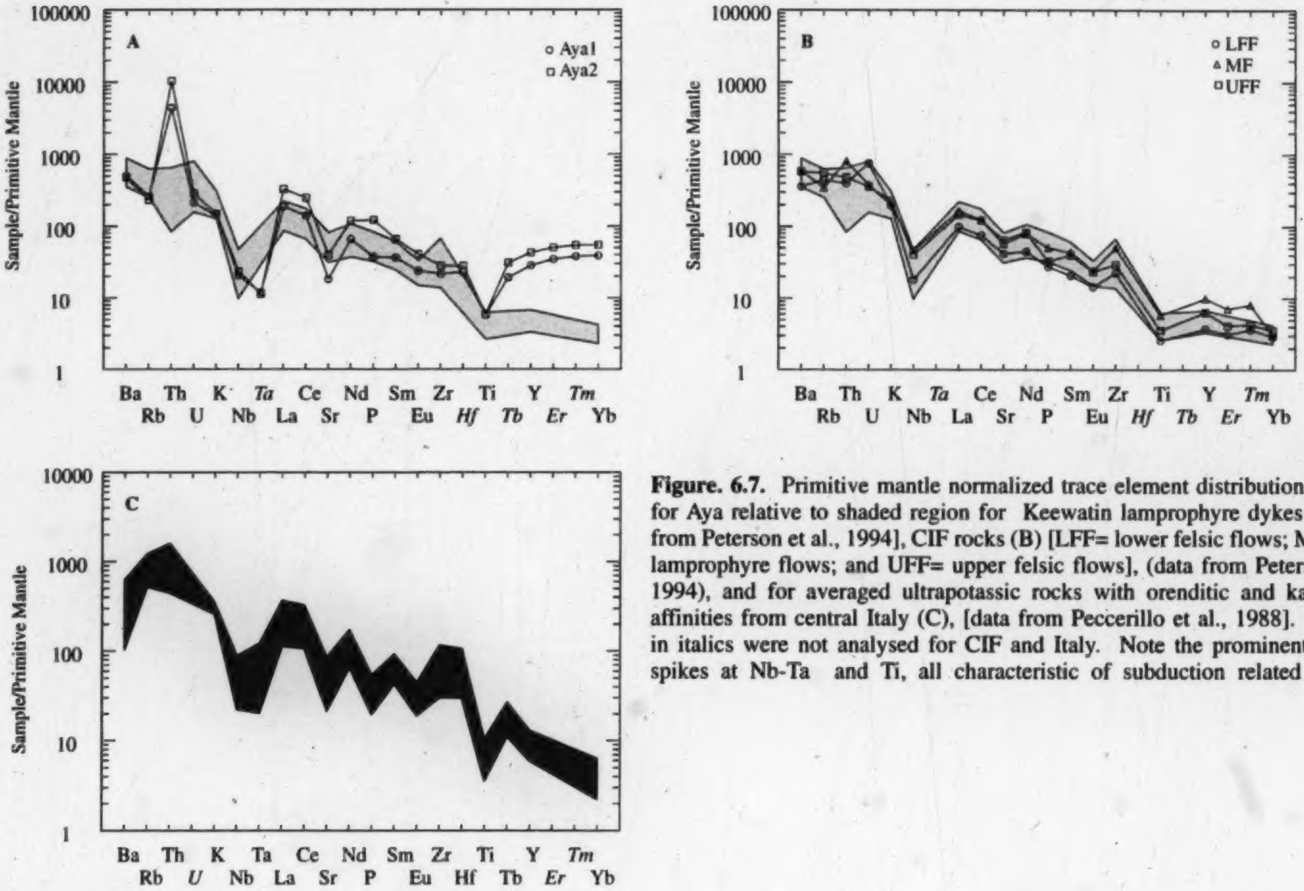


Figure. 6.7. Primitive mantle normalized trace element distribution diagrams for Aya relative to shaded region for Keewatin lamprophyre dykes (A) [data from Peterson et al., 1994], CIF rocks (B) [LFF= lower felsic flows; MF= mafic lamprophyre flows; and UFF= upper felsic flows], (data from Peterson et al., 1994), and for averaged ultrapotassic rocks with orenditic and kamafugitic affinities from central Italy (C), [data from Peccerillo et al., 1988]. Elements in italics were not analysed for CIF and Italy. Note the prominent negative spikes at Nb-Ta and Ti, all characteristic of subduction related magmas.

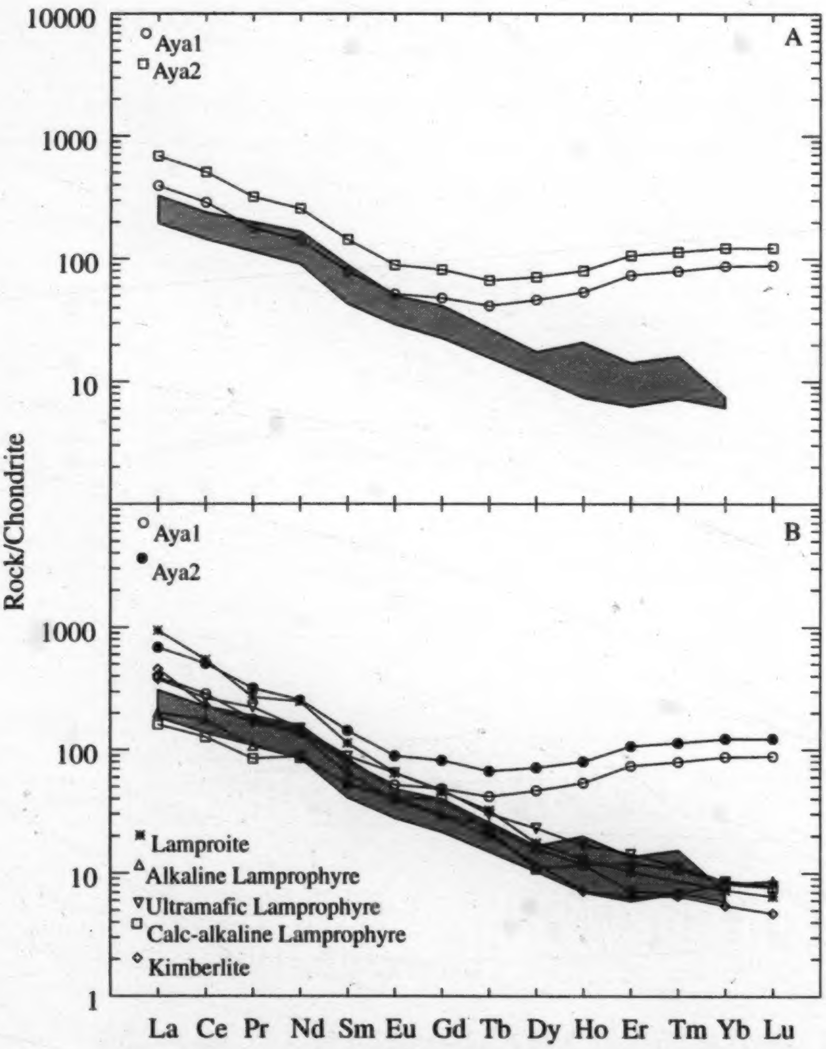


Figure 6.8. Chondrite normalized REE plots for Aya, lamproites, kimberlites, lamprophyres, and shaded field for CIF, LFF, MF, and UFF (A, B). Note the HREE enrichment in Aya along with the similar LREE abundances compared to Lamproites, Kimberlites, and Ultramafic Lamprophyres. Average REE abundances for Kimberlite, lamproite, and lamprophyre from (Rock 1991) and CIF from Peterson et al. (1994).

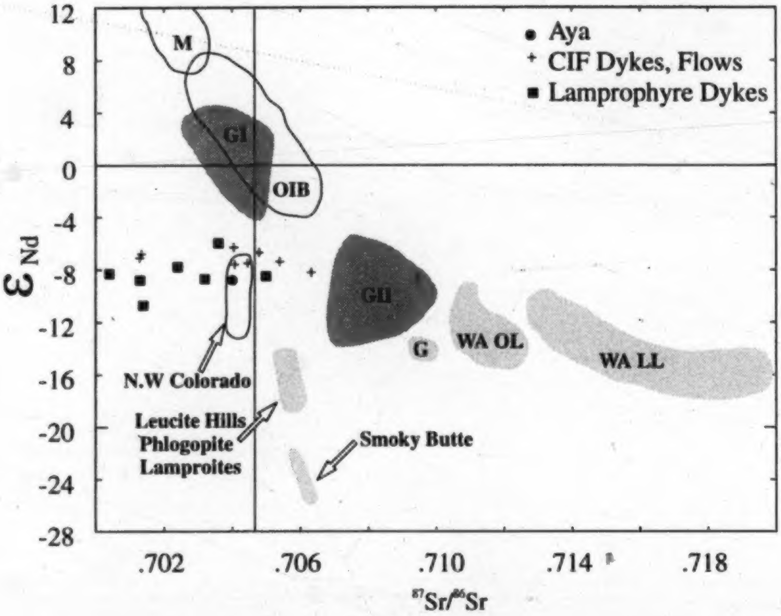


Figure 6.9. Initial isotopic compositions of Sr and ε_{Nd} for Aya dyke, CIF ultrapotassic rocks (dykes and flows), and lamprophyre dykes (District of Keewatin) relative to generalized fields for MORB (M), OIB, Group I Kimberlites (GI), Group II Kimberlites (GII), and lamproites: Gaussberg (G); Western Australia Olivine lamproites (WA OL); and Western Australia Leucite lamproites (WA LL). Generalized fields with data sources taken from Wilson (1989), Mitchell (1995b), Mitchell and Bergman (1991), and Thompson et al. (1989). CIF and Keewtain data from Peterson (1991).

Table 6.1. Representative compositions of Aya phlogopites. Note the evolutionary trend of the the phlogopites from relatively unevolved (high mg#) 1-5 phlogopites, to progressively more evolved (trends B to J to D to F).

	1-C	1-R	2-C	2-R	3-C	3-R	4-CK	4-RK	5-C	5-R
SiO_2	39.31	39.31	38.67	39.92	38.71	39.14	39.02	39.40	38.98	39.17
TiO_2	1.51	1.43	1.88	1.51	1.86	1.81	2.09	1.85	1.79	1.65
Al_2O_3	14.06	14.19	13.96	13.88	13.86	14.08	13.89	13.56	13.99	14.30
Cr_2O_3	0.43	0.03	0.95	0.57	1.52	1.53	1.13	0.76	1.26	1.37
FeO	9.74	9.71	9.98	9.37	10.42	10.22	9.99	10.13	9.94	10.14
MnO	0.05	0.06	0.10	0.09	0.06	0.05	0.07	0.09	0.04	0.05
MgO	19.72	19.54	18.73	19.65	17.96	18.42	18.03	18.30	18.38	18.48
BaO	0.87	0.74	0.56	0.65	0.59	0.77	0.71	0.62	0.79	0.78
CaO	0.00	0.00	0.05	0.02	0.05	0.05	0.02	0.18	0.02	0.03
NiO	0.11	0.10	0.11	0.10	0.09	0.10	0.08	0.11	0.10	0.13
Na_2O	0.22	0.22	0.09	0.20	0.22	0.20	0.18	0.20	0.21	0.20
K_2O	9.16	9.34	9.35	9.25	8.97	9.02	9.34	9.30	9.26	8.78
F	0.74	0.66	0.70	0.76	0.52	0.57	0.65	0.71	0.59	0.58
Cl	0.02	0.02	0.02	0.01	0.01	0.01	0.01	0.00	0.00	0.02
Total	95.63	95.06	94.84	95.65	94.62	95.72	94.95	94.92	95.10	95.43
Structural formula based on 11 oxygens:										
Si	2.877	2.888	2.860	2.909	2.870	2.868	2.883	2.910	2.875	2.872
Ti	0.083	0.079	0.105	0.083	0.104	0.100	0.116	0.103	0.100	0.091
Al	1.213	1.229	1.217	1.192	1.211	1.216	1.209	1.180	1.216	1.236
Cr	0.025	0.002	0.056	0.033	0.089	0.089	0.066	0.045	0.074	0.080
Fe	0.596	0.597	0.617	0.571	0.646	0.626	0.617	0.625	0.613	0.622
Mn	0.003	0.003	0.006	0.005	0.004	0.003	0.005	0.005	0.003	0.003
Mg	2.151	2.140	2.065	2.134	1.985	2.012	1.986	2.015	2.020	2.020
Ba	0.025	0.021	0.016	0.019	0.017	0.022	0.020	0.018	0.023	0.022
Ca	0.000	0.000	0.004	0.002	0.004	0.004	0.002	0.015	0.002	0.002
Ni	0.006	0.006	0.006	0.006	0.006	0.006	0.005	0.007	0.006	0.008
Na	0.031	0.032	0.014	0.028	0.032	0.028	0.026	0.028	0.029	0.028
K	0.855	0.875	0.883	0.860	0.848	0.843	0.881	0.877	0.871	0.821
F	0.171	0.154	0.163	0.175	0.122	0.131	0.151	0.165	0.137	0.134
Cl	0.002	0.002	0.003	0.001	0.002	0.001	0.001	0.000	0.000	0.003
CAT	8.038	8.027	8.013	8.017	7.940	7.948	7.968	7.993	7.968	7.941
mg#	78.30	78.20	76.99	78.89	75.45	76.26	76.28	76.31	76.72	76.46

Total Fe expressed as FeO. CAT = cation total; mg#= 100Mg/(Mg+Fe); (C) core; (R) rim; (K) kinked.

Table 6.1. (continued).

	B1-C	B1-R	B2-C	B2-R	B3-C	B3-R	J1-C	J1-R	J2-C	J2-R
SiO_2	38.20	38.09	39.32	39.25	39.17	40.23	37.99	38.39	38.37	38.86
TiO_2	1.80	1.72	2.01	1.55	1.52	1.62	1.90	1.83	1.91	1.98
Al_2O_3	14.47	14.01	14.29	14.41	14.75	14.36	14.43	14.46	14.07	14.55
Cr_2O_3	0.80	0.54	1.31	0.08	0.07	0.07	0.64	0.21	0.62	0.88
FeO	10.84	11.12	11.01	10.76	10.50	10.52	13.73	13.73	13.09	12.96
MnO	0.06	0.09	0.08	0.07	0.04	0.05	0.07	0.08	0.06	0.07
MgO	17.85	17.92	18.18	19.38	18.64	19.42	16.55	17.21	17.03	17.44
BaO	0.66	1.04	0.73	1.11	0.80	0.78	0.76	0.81	0.76	0.60
CaO	0.02	0.03	0.00	0.09	0.02	0.00	0.01	0.00	0.00	0.14
NiO	0.07	0.09	0.08	0.09	0.10	0.09	0.06	0.00	0.05	0.04
Na_2O	0.22	0.15	0.19	0.15	0.14	0.11	0.18	0.08	0.23	0.26
K_2O	9.34	8.90	9.18	8.93	9.05	9.51	9.18	8.68	9.13	8.87
F	0.60	0.64	0.67	0.80	0.75	0.89	0.46	0.48	0.52	0.52
Cl	0.01	0.01	0.01	0.03	0.00	0.00	0.04	0.01	0.02	0.01
Total	94.68	94.09	96.77	96.34	95.25	97.29	95.80	95.76	95.64	96.94
Structural formula based on 11 oxygens:										
Si	2.842	2.858	2.860	2.864	2.878	2.898	2.829	2.844	2.852	2.837
Ti	0.101	0.097	0.110	0.085	0.084	0.088	0.106	0.102	0.107	0.108
Al	1.269	1.239	1.225	1.239	1.277	1.219	1.267	1.262	1.233	1.252
Cr	0.047	0.032	0.075	0.004	0.004	0.004	0.038	0.012	0.037	0.051
Fe	0.674	0.698	0.669	0.657	0.645	0.634	0.855	0.851	0.814	0.791
Mn	0.004	0.006	0.005	0.004	0.003	0.003	0.005	0.005	0.004	0.004
Mg	1.979	2.004	1.971	2.108	2.041	2.085	1.838	1.901	1.886	1.898
Ba	0.019	0.031	0.021	0.032	0.023	0.022	0.022	0.023	0.022	0.017
Ca	0.002	0.003	0.000	0.007	0.002	0.000	0.001	0.000	0.000	0.011
Ni	0.004	0.006	0.005	0.005	0.006	0.005	0.003	0.000	0.003	0.002
Na	0.032	0.022	0.027	0.021	0.020	0.016	0.026	0.012	0.033	0.036
K	0.886	0.852	0.851	0.831	0.848	0.874	0.872	0.820	0.866	0.826
F	0.141	0.152	0.154	0.185	0.175	0.204	0.108	0.111	0.123	0.120
Cl	0.002	0.002	0.001	0.004	0.000	0.000	0.005	0.001	0.002	0.001
CAT	8.002	8.000	7.975	8.045	8.006	8.052	7.975	7.945	7.981	7.955
mg#	74.59	74.18	74.65	76.24	75.99	76.69	68.24	69.09	69.87	70.57

Table 6.1. (continued).

	D1-C	D1-R	D2-C	D2-R	D3	D4	F1-C	F1-R	F2
SiO_2	38.00	38.06	38.49	39.16	38.75	39.29	37.49	37.78	37.76
TiO_2	2.04	1.75	1.96	1.87	1.84	1.92	1.83	1.69	1.65
Al_2O_3	14.56	14.55	14.00	13.46	14.65	14.72	14.25	14.02	14.13
Cr_2O_3	0.00	0.00	0.00	0.00	0.20	0.00	0.79	0.08	0.23
FeO	14.72	14.44	14.65	14.45	14.15	14.13	18.06	17.40	18.37
MnO	0.09	0.08	0.06	0.04	0.14	0.08	0.04	0.06	0.11
MgO	15.89	16.01	16.04	16.18	16.12	15.78	13.65	13.80	14.43
BaO	1.01	0.83	1.02	0.85	1.02	0.97	0.60	0.61	0.60
CaO	0.02	0.19	0.00	0.03	0.03	0.00	0.18	0.16	0.15
NiO	0.06	0.02	0.02	0.02	0.10	0.04	0.00	0.04	0.10
Na_2O	0.07	0.11	0.18	0.17	0.16	0.19	0.22	0.18	0.17
K_2O	9.00	8.82	8.41	8.39	8.73	8.10	8.37	9.04	8.79
F	0.54	0.48	0.48	0.51	0.66	0.55	0.35	0.54	0.36
Cl	0.03	0.03	0.05	0.02	0.05	0.02	0.06	0.06	0.05
Total	95.79	95.15	95.13	94.94	96.31	95.55	95.72	95.21	96.75
Structural formula based on 11 oxygens:									
Si	2.841	2.853	2.883	2.929	2.868	2.907	2.838	2.875	2.836
Ti	0.115	0.099	0.111	0.105	0.103	0.107	0.104	0.096	0.093
Al	1.283	1.285	1.236	1.186	1.278	1.284	1.271	1.258	1.251
Cr	0.000	0.000	0.000	0.000	0.012	0.000	0.047	0.005	0.014
Fe	0.920	0.905	0.918	0.904	0.876	0.875	1.143	1.108	1.154
Mn	0.005	0.005	0.004	0.003	0.009	0.005	0.003	0.004	0.007
Mg	1.770	1.789	1.791	1.804	1.779	1.741	1.541	1.566	1.616
Ba	0.030	0.024	0.030	0.025	0.030	0.028	0.018	0.018	0.018
Ca	0.001	0.015	0.000	0.003	0.002	0.000	0.014	0.013	0.012
Ni	0.004	0.001	0.001	0.001	0.006	0.002	0.000	0.002	0.006
Na	0.011	0.015	0.026	0.025	0.023	0.027	0.033	0.026	0.024
K	0.858	0.843	0.804	0.801	0.825	0.765	0.808	0.878	0.842
F	0.127	0.113	0.113	0.120	0.155	0.129	0.083	0.130	0.085
Cl	0.004	0.004	0.006	0.002	0.006	0.003	0.008	0.008	0.007
CAT	7.969	7.951	7.922	7.908	7.970	7.872	7.910	7.987	7.964
mg#	65.80	66.41	66.12	66.62	67.01	66.56	57.40	58.57	58.34

Table 6.2. Representative compositions for Aya calcic-amphibole.

	1	2	3	4	5	6
SiO_2	55.71	53.46	56.99	54.23	56.22	55.69
TiO_2	0.13	0.10	0.05	0.08	0.04	0.04
Al_2O_3	0.57	1.91	0.49	0.37	0.65	1.19
Cr_2O_3	0.02	0.05	0.19	0.07	0.00	0.02
FeO*	6.46	9.89	3.15	4.83	8.23	7.10
MnO	0.24	0.29	0.13	0.15	0.18	0.19
MgO	20.72	18.24	22.75	21.29	19.92	20.35
CaO	13.15	12.26	13.37	14.16	13.01	12.85
BaO	0.00	0.02	0.00	0.00	0.01	0.05
Na_2O	0.11	0.37	0.11	0.11	0.10	0.24
K_2O	0.18	0.25	0.14	0.11	0.05	0.05
F	0.16	0.18	0.13	0.12	0.13	0.16
Cl	0.01	0.02	0.01	0.02	0.01	0.00
Total	97.40	96.95	97.44	95.46	98.48	97.85
Structural formula based on 23 oxygens:						
Si	7.839	7.691	7.881	7.769	7.863	7.808
Ti	0.014	0.010	0.005	0.008	0.005	0.004
Al	0.094	0.324	0.079	0.062	0.107	0.197
Cr	0.002	0.006	0.020	0.008	0.000	0.002
Fe	0.760	1.190	0.364	0.579	0.962	0.833
Mn	0.029	0.036	0.015	0.018	0.022	0.023
Mg	4.346	3.911	4.691	4.546	4.152	4.253
Ca	1.983	1.890	1.981	2.173	1.949	1.931
Ba	0.000	0.001	0.000	0.000	0.001	0.003
Na	0.031	0.102	0.030	0.031	0.028	0.065
K	0.032	0.046	0.025	0.020	0.009	0.008
F	0.073	0.083	0.057	0.052	0.057	0.072
Cl	0.002	0.005	0.001	0.004	0.001	0.000
CAT	15.205	15.295	15.149	15.270	15.155	15.197
mg#	85.11	76.67	92.80	88.70	81.19	83.63
K/(K+Na)	0.51	0.31	0.46	0.40	0.23	0.11

CAT= cation total; * Total Fe expressed as FeO; mg#= 100Mg/(Mg+Fe).

Table 6.3. Representative compositions for Aya apatite.

	1	2	3	4	5	6	7	8
SiO_2	0.94	0.75	1.13	1.97	0.07	0.06	0.66	0.30
FeO*	0.39	0.50	0.34	0.15	0.10	0.11	0.38	0.12
MnO	0.06	0.05	0.03	0.07	0.02	0.01	0.04	0.01
MgO	0.11	0.01	0.14	0.02	0.00	0.00	0.02	0.00
CaO	54.06	53.08	52.29	51.08	54.69	54.05	53.34	54.49
SrO	1.88	1.33	1.51	1.34	1.71	1.74	1.36	1.69
UO_2	n.d	n.d	n.d	n.d	n.d	n.d	n.d	n.d
P_2O_5	40.48	41.03	40.28	38.94	41.51	42.45	41.27	41.05
La_2O_3	0.17	0.07	0.20	0.58	0.05	0.00	0.04	0.04
Ce_2O_3	0.45	0.45	0.67	1.88	0.03	0.00	0.18	0.09
Nd_2O_3	0.37	0.31	0.35	1.31	0.06	0.02	0.27	0.18
F	2.94	3.04	2.73	2.81	3.28	2.91	2.89	3.30
Cl	0.10	0.07	0.10	0.07	0.00	0.01	0.06	0.02
Total	100.68	99.38	98.59	99.01	100.14	100.12	99.27	99.89
Structural formula based on 25 oxygens:								
Si	0.159	0.127	0.194	0.342	0.011	0.010	0.112	0.051
Fe	0.056	0.071	0.049	0.022	0.015	0.015	0.053	0.016
Mn	0.008	0.007	0.004	0.011	0.003	0.002	0.006	0.002
Mg	0.027	0.004	0.035	0.006	0.000	0.000	0.005	0.000
Ca	9.808	9.679	9.619	9.492	9.914	9.717	9.702	9.921
Sr	0.185	0.131	0.151	0.135	0.168	0.169	0.134	0.167
U	n.d	n.d	n.d	n.d	n.d	n.d	n.d	n.d
P	5.803	5.911	5.856	5.718	5.946	6.031	5.932	5.905
La	0.011	0.004	0.013	0.037	0.003	0.000	0.003	0.002
Ce	0.028	0.028	0.042	0.119	0.002	0.000	0.011	0.005
Nd	0.022	0.019	0.021	0.081	0.004	0.001	0.016	0.011
F	1.574	1.635	1.480	1.542	1.754	1.542	1.550	1.773
Cl	0.028	0.019	0.029	0.019	0.000	0.002	0.018	0.005
CAT	17.708	17.634	17.492	17.523	17.819	17.488	17.542	17.859

CAT = cation total; * Total Fe expressed as FeO; n.d= not detected.

Table 6.4. Rb-Sr data on two phlogopite mineral separatres from Aya1.

	phl1	phl2
Sr (ppm)	53.71	45.38
Rb (ppm)	346.74	739.15
$^{87}Sr/^{86}Sr$ (meas.)	1.21762	1.31393
$^{87}Sr/^{86}Sr$ (corr.)	1.21766	1.31397
2 sigma uncertainty	0.000019	0.000023
$^{87}Rb/^{86}Sr$	21.10113	53.23946
(assuming initial = 0.705)		
Age (Ma)	1690.50	800.95
(assuming initial = 0.710)		
Age (Ma)	1674.21	794.41
(assuming initial = 0.715)		
Age (Ma)	1657.91	787.87

(meas.) = measured value, (corr.) = measured value + 0.00004.

Sr and Rb concentrations determined by isotope dilution.

Table 6.5. Major element analyses for the Aya ultrapotassic dyke.

wt. %	Aya1	Aya2	LFF	MF	UFF	KDS1	KDS2	UML
SiO_2	37.96	39.27	59.32	53.54	53.86	49.50	55.40	29.00 +/- 5.4
TiO_2	1.26	1.27	0.56	0.77	1.26	1.35	1.07	3.20 +/- 1.0
Al_2O_3	7.91	7.94	13.03	11.44	13.14	9.70	12.80	6.60 +/- 3.6
Fe_2O_3	8.77*	8.51*	3.46	5.20	5.26	2.90	2.40	6.70 +/- 3.4
FeO	-	-	2.12	1.98	3.70	3.40	2.10	6.80 +/- 1.9
MnO	0.13	0.11	0.08	0.09	0.12	0.10	0.06	0.27 +/- 0.08
MgO	16.15	8.32	4.53	9.59	5.59	13.30	6.41	13.30 +/- 4.8
CaO	10.18	14.52	4.49	5.02	4.53	6.06	6.73	15.70 +/- 3.9
Na_2O	0.29	0.64	3.02	1.57	2.29	0.43	0.38	1.00 +/- 0.9
K_2O	4.24	4.47	5.93	6.83	6.12	6.25	8.56	2.10 +/- 1.0
P_2O_5	0.81	2.65	0.60	0.71	1.10	1.83	1.02	1.30 +/- 0.9
H_2O+	0.34	0.45	-	-	-	-	-	-
H_2O-	0.75	0.23	-	-	-	-	-	-
CO_2	8.13	10.56	1.02	0.58	0.56	2.80	2.60	9.60 +/- 5.6
S	-	-	-	-	-	-	-	-
LOI	9.90	10.35	-	-	-	-	-	-
Total	97.59	98.03	98.16	97.32	97.53	97.62	99.53	-
(n)	1	1	12	32	8	1	1	171
PI	0.64	0.74	0.87	0.87	0.79	0.77	0.77	-
UPI	9.62	4.60	1.29	2.86	1.76	9.56	14.82	-
PPI	0.58	0.61	0.49	0.65	0.50	0.70	0.72	-

CIF lavas (data from Peterson et al., 1994): LFF= lower felsic flows; MF= mafic lamprophyre flows; UFF= upper felsic flows; KDS1-2=Keewatin laprophyre dyke suite. UML= averaged analyses of melilite-free aillikites and damkjernites, ultramafic lamprophyres (Rock, 1986).1-3 Kamafugites: 1, Katungite, Katunga (Holmes 1937, p.205); 2, Mafurite (Holmes 1942, p.212); 3, ugandite (Holmes, 1956, p.15). 4-6 lamprophyres (Rock, 1991): 4, Calc-alkaline lamprophyres; 5, Alkaline lamprophyres; 6, Ultramafic lamprophyres.

PI peralkalinity index (molar): $(K_2O+Na_2O)/(Al_2O_3) >0.8$; UPI ultrapotassic index (molar): $(K_2O)/(Na_2O)>3$;

PPI perpotassic index (molar): (K2O)/(Al2O3)>0.8. LOI (loss on ignition); (n) number of samples.

All totals are quoted from referenced texts, except samples from this work in which totals are calculated on a CO_2, H_2O^+, and H_2O^- free basis; * total Fe calculated as Fe2O3.

Table 6.5. (continued).

wt. %	1	2	3	4	5	6
SiO_2	35.37	39.06	43.85	51.00	42.50	32.30
TiO_2	3.87	4.36	3.12	1.10	2.90	3.10
Al_2O_3	6.50	8.18	7.32	14.00	13.70	6.70
Fe_2O_3	7.23	4.61	3.63	8.20	12.00	13.60
FeO	5.00	4.98	6.84	-	-	-
MnO	0.24	0.26	0.20	0.13	0.20	0.22
MgO	14.08	17.66	15.37	7.00	7.10	15.00
CaO	16.79	10.40	11.13	7.00	10.30	14.00
Na_2O	1.32	0.18	2.50	2.70	3.00	1.00
K_20	4.09	6.98	3.28	3.10	2.00	1.90
P_2O_5	0.74	0.61	0.52	0.60	0.74	1.00
H_20+	-	-	-	-	-	-
H_20-	-	-	-	-	-	-
CO_2	-	-	-	2.00	2.00	6.50
S	-	-	-	0.12	0.20	0.20
LOI	-	-	-	-	-	-
Total	95.48	97.60	97.93	99.40	99.70	99.00
(n)	1	1	1	1590	854	456
PI	1.02	0.96	1.05	0.56	0.52	0.55
UPI	2.04	25.51	0.86	0.76	0.44	1.25
PPI	0.68	0.92	0.48	0.24	0.16	0.31

Table 6.6. Trace element analyses (ppm) for Aya.

	Aya1	Aya2	LFF	MF	UFF	KDS1	KDS2	4	5	6
Cr	1451	-	133	336	122	580	280	370	97	480
Co	59	45	26	43	37			36	38	75
Ni	602	73	54	159	56	540	230	150	65	430
Rb	164	147	284	352	222	373	181	70	50	65
Sr	386	848	892	1359	1213	974	668	715	990	950
Y	129	195	17	29	45	29	15	23	31	26
Zr	243	314	253	330	567	748	621	190	313	311
Hf	7	9	-	-	-			5.2	6.9	6.5
Nb	15	17	13	29	33	17	17	13	101	120
Ta	0.5	0.5	-	-	-			0.9	5.0	9.5
Ba	3467	3356	2531	4109	4192	6040	3000	1050	930	1100
La	129.3	225.3	68.0	101.0	114.0	150	102	53	66	125
Ce	249.0	439.2	133.0	217.0	219.0	316	193	110	125	230
Pr	23.2	41.6	-	-	-			11	14	29
Nd	89.3	161.2	61.0	113.0	107.0	114	76	56	54	95
Sm	16.0	29.1	9.3	17.9	19.2	27	12.6	10.50	10.80	18.00
Eu	4.0	6.9	2.4	4.0	4.1	5.7	2.6	3.10	3.10	5.00
Gd	13.2	22.6	6.7	12.2	11.5	-	-	11.00	8.20	13.00
Tb	2.1	3.3	-	-	-	-	-	1.10	1.20	1.50
Dy	15.9	24.4	4.0	6.3	6.4	-	-	3.70	5.40	7.90
Ho	4.1	6.2	0.6	0.9	1.7	1.1	0.5	0.90	0.90	1.30
Er	16.6	24.0	1.5	2.0	3.4	-	-	1.60	2.70	3.20
Tm	2.8	4.0	0.3	0.3	0.6	-	-	0.24	0.38	0.40
Yb	19.2	27.0	1.4	1.8	1.5	1.57	1.52	1.80	1.80	1.90
Lu	3.0	4.2	-	-	-	-	-	0.26	0.29	0.27
$(La/Yb)_N$	4	5	27	32	43	54	38	17	21	37
Th	376.765	885.381	34	41	69	48.6	23	9	9	10
U	4.509	6.047	16	7.6	8	16.8	5.2	3	2.2	5

Sample headings as from Table 6.5.

Table 6.7. Strontium and Neodymium isotopic compositions for Aya.

	Aya1	Aya2
^{143}Nd /^{144}Nd (meas.)	0.510923	0.510894
^{143}Nd /^{144}Nd (corr.)	0.510968	0.510939
2 sigma mean	0.000007	0.000011
Epsilon ^{143}Nd (meas.)	-32.6	-33.1
Sm (ppm)	16.32	29.50
	[16.02]	[29.09]
Nd (ppm)	106.16	196.78
	[89.29]	[161.16]
T crystallization (Ma)	1792	1792
^{143}Nd /^{144}Nd (T)	0.509872	0.509870
^{143}Nd /^{144}Nd CHUR (T)	0.510319	0.510319
Epsilon ^{143}Nd (T)	-8.76	-8.80
TDM (Goldstein)	2.81	2.79
^{87}Sr/^{86}Sr (meas.)	0.734527	0.716700
^{87}Sr/^{86}Sr (corr.)	0.734567	0.716740
2 sigma mean	0.000020	0.000017
^{87}Sr/^{86}Sr (T)	0.704000	0.704000
^{87}Rb/^{86}Sr	1.186040	0.494280
Rb (ppm)	161.4	146.2
	[164.37]	[147.44]
Sr (ppm)	444.79	966.64
	[385.74]	[847.64]

(meas.) = measured value, (corr.) = mesured value + 0.000045 (Nd) and + 0.00004 (Sr).

Sm, Nd, Sr, Rb determined by isotope dilution; values in brackets determined by ICP/MS.

Normalization values ^{86}Sr/^{88}Sr = 0.1194 and ^{146}Nd/^{144}Nd = 0.7219.

Epsilon ^{143}Nd (measured) calculated using ^{143}Nd/^{144}Nd = 0.512638.

Epsilon ^{143}Nd (T) calculated using ^{143}Nd/^{144}Nd CHUR (T) values.

CHAPTER 7

CONCLUSIONS

Recognition Of Meliadine Dykes As Kimberlite

A combination of textural criteria, modal abundances of typomorphic minerals (specifically phlogopite and spinel), and element compositions of those minerals were used to classify the Meliadine dykes as kimberlites. Petrologically unrelated rocks such as orangeites, lamproites, and lamprophyres contain typomorphic mineral assemblages that may be used to discriminate between such rocks (Mitchell, 1995a). These so called typomorphic mineral assemblages have characteristic compositions that reflect those of the parental magma, allowing these assemblages to be used to distinguish rock types (Mitchell, 1995a).

Petrographically, the Peter kimberlite dykes consist of altered olivine macrocrysts and microphenocrysts (35-40 modal %), microphenocryst and groundmass phlogopite (1-4 %), microphenocrysts and groundmass spinel (2-10 %), with the remainder consisting of carbonate groundmass. Garnet microcrysts/xenoliths were also recovered from a heavy mineral fraction. The K-L kimberlite dykes are mineralogically similar to Peter with the exception of phlogopite (absent): 30-50 modal % altered olivine, 4-10 % spinel, < 1 % apatite, and groundmass carbonate accounting for the remainder. Garnet and perovskite were also recovered from a heavy mineral fraction. Based on mineralogy and texture, the K-L dykes are classified as hypabyssal macrocrystal carbonate kimberlites (carbonate defined as dolomite + calcite), and the Peter dykes as hypabyssal macrocrystal phlogopite-carbonate kimberlites [classification from Clement and Skinner, (1985), and Skinner and Clement, (1979)].

The Meliadine dykes consist of 2 generations of olivine pseudomorphed completely by an intimate mixture of Fe-rich serpentine, ± carbonate and sepiolite. One generation of olivine consists of rounded-to-anhedral olivine macrocrysts, and the later generation consists of subhedral-to-euhedral phenocryst/microphenocryst olivine. Olivine is ubiquitous and a characteristic constituent in kimberlites, with two generations of olivine a characteristic feature of kimberlites and orangeites (essentially identical) [Mitchell, 1995b, 1986]. Lamproites, minettes, and ultramafic lamprophyres characteristically do not contain two generations of olivine (or olivine is a rare constituent as in minettes), and when present, the habit and paragenesis differs from that of kimberlites (Mitchell, 1995a,b).

Phlogopite occurs exclusively in the Peter I and II dykes as microphenocryst and groundmass grains. Phlogopite is an effective discriminant (i.e., typomorphic mineral phase) between kimberlites and various other alkaline ultramafic rocks (orangeites, lamproites, and lamprophyres) [Fig. 3.5]. Compositional variation observed in Peter mica is one of Ti-depletion, increasing Al (typically), and decreasing Fe (typically). Such an evolutionary trend is distinctive of kimberlites (Mitchell, 1995b, 1986).

The bulk of the spinels analysed in the Meliadine dykes are magnesian ulvöspinel-ulvöspinel-magnetites that belong to Magmatic Trend 1 spinels, the characteristic spinel compositional trend unique to kimberlites. Analysed MUM cores may(may not) be mantled by Ti-bearing magnetite rims and(or) atolls. The Meliadine spinels are indicative of the more evolved portion of Magmatic Trend 1 spinels: Ti-rich, Cr-poor, Fe-enriched spinels, although a small number of early forming TIMAC spinels were present.

Geochemistry for the Meliadine dykes supports the interpretation that they are evolved kimberlites. All samples are carbonate-rich with low SiO_2 and MgO, combined with high CaO and CO_2. These characteristics are comparable with other evolved carbonate-rich kimberlites from South Africa, and West Greenland which all display similar major element patterns. Trace element abundances are consistent with an evolved character; compatible element concentrations (i.e., Cr and Ni) are low, a feature typical of evolved carbonate-rich kimberlites relative to genetically related less evolved kimberlites (Scott, 1979; Mitchell, 1986). Incompatible element abundances are also similar to other evolved kimberlites. LREE-enrichment observed in the Meliadine dykes is typical of kimberlites, however, HREE are more enriched compared to average kimberlite. HREE-enrichment was not attributed to crustal contamination, unusual source mineralogy or geochemistry (i.e., ophiolitic melt residues), concentration of garnet, or differentiation and(or) immiscibility of silicate and carbonate liquids. The exact nature of this enrichment is not clear and is unexplainable at this time.

Strontium and Neodymium isotopes data for the Meliadine kimberlite dykes indicate that they may be sub-divided into two distinct groups: the first group consists of the K-L dykes, that contain non-radiogenic initial $^{87}Sr/^{86}Sr$ (mean of 0.70403) and positive ε_{Nd} values (mean +4.6); Peter defines the second isotopic group (albeit a single sample) and consists of slightly more radiogenic initial $^{87}Sr/^{86}Sr$ (0.70526) and lower positive ε_{Nd} (+2.2). These isotopic characteristics are comparable to Group I kimberlites from South African kimberlites (Smith, 1983), and from occurrences in India, United States, Greenland, Zaire, and Russia (Basu and Tatsumoto, 1980;

Weis and Demaiffe, 1985; Nelson, 1989). In general Group I kimberlites (archetypal kimberlites) are predominantly non-micaceous, with ε_{Nd} values of –0.5 to +4.1, and generally non-radiogenic initial $^{87}Sr/^{86}Sr$ ranging from 0.7033 to 0.7049 (Smith, 1983). These isotopic characteristics are interpreted to indicate that Group I kimberlites have been derived from source regions that are relatively undifferentiated to slightly depleted (i.e., higher Sm/Nd, $+\varepsilon_{Nd}$) with respect to CHUR, similar to the source regions for oceanic island basalts (OIB) [Basu and Tatsumoto 1980; Smith 1983; LeRoex, 1986]. The isotopic results for the Meliadine kimberlites require that they were derived from a time-integrated LREE-depleted asthenospheric mantle source similar to that from which Group I kimberlites are derived.

Overall, the Meliadine dykes are kimberlites that display evolved characteristics based on mineral chemistry (spinels- most evolved portion of the spinel evolutionary trend; Ti-rich, Cr-poor spinels), geochemical data (major and trace elements). The dykes are also poor in mantle-derived megacrysts, and essentially consist of altered microphenocryst olivine, carbonate, and spinel, with minor phlogopite, apatite, and perovskite; all features typical of evolved kimberlites.

Diamond Potential Of The Meliadine Kimberlites

The lack of indicator minerals observed in the Meliadine kimberlite dykes is the direct result of the highly evolved character of the dykes. Traditionally used diamond indicator minerals such as G10 garnets (sub-calcic Cr-rich pyropes) and garnets of eclogitic affinity were absent from the Meliadine kimberlites. The lack of these key minerals indicate that the Meliadine kimberlites have an extremely low diamond potential.

Geochronology

U-Pb perovskite geochronology using measured $^{206}Pb/^{204}Pb$ against measured $^{238}U/^{204}Pb$ to construct a two point monomineralic isochron diagram yeilded an Early Jurassic age of 192 ± 13 Ma with initial $^{206}Pb/^{204}Pb$ of 20.91 ± 0.46. The isochron age is of uncertain reliability and is therefore accepted as a best estimate for the age of emplacement. The $^{206}Pb/^{238}U$ age was used because the result is not affected by a common Pb correction, but in fact gives information on the common Pb isotopic composition.

The Meliadine kimberlite dykes represent the first Early Jurassic kimberlites to found and dated within the Archean Churchill Province. Dated kimberlites in Canada occur in the Paleozoic, Mesozoic, and Cenozoic, with the Meliadine dykes being the only known and dated kimberlites in the Churchill Province. The 192 ± 13 Ma age must be confirmed.

Aya Ultrapotassic Dyke

The Aya dyke was intersected in diamond drill hole ML96-136 (cf. Table 1.1) and consisted of 45-55 modal % phlogopite, 30-35 % amphibole, ≤ 1 % apatite, 5-10 % carbonate, and trace opaques. Based on mineralogy, the dyke is considered to be a lamprophyre, with the typomorphic mineral phlogopite displaying an evolutionary trend typical to that found in minettes. With the consideration of major element data (low SiO_2, high Al_2O_3, and high CaO) in conjunction with the presence of phlogopite + amphibole, and the absence of melilite, feldspathoids, and alkali feldspar, the dyke is best classified as an ultramafic lamprophyre.

Age dating of the dyke by Rb-Sr whole-rock isochron yielded an age of 1792 ± 32 Ma. This age correlates with the extinsive Early Proterozoic (ca. 1.84 Ga) ultrapotassic rocks of the Christopher Island Formation (CIF), that lie ~ 400 km to the west of the Meliadine property within the Baker Lake Group, Churchill Province, Canada. Although the Aya dyke is spatially disparate to the CIF lavas, and differs mineralogically, trace element data, and Sr-Nd isotopes confirm Ayas association with the CIF.

The Aya dyke and the Meliadine kimberlites both share a similar pattern in HREE-enrichment. This might lead one to conclude that these rocks were derived from a similar source region within the mantle. This is however not a plausible scenario because Sr and Nd isotopes differ considerably for each rock type, therefore indicating different source regions. An explanantion for such an enrichment in HREE is still lacking at this time.

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APPENDIX I

Probe Standards and Analytical Results

Garnet

ELEMENT	STANDARD
Na, Ti	Kaersuitite
Mg, Al, Si, Ca, Fe	Pyrope
Cr	Chromite
Mn	Willemite
Ni	Fo_{90}

Amphibole

ELEMENT	STANDARD
Na, Mg, Al, Si, Ca, Ti, Fe, K	Kaersuitite
Cr	Chromite
Mn	Willemite
F	Apatite
Cl	Tugtupite
Ba	Sanadine

Appendix I Legend

- c= core
- r= rim
- a= atoll
- z= zoned
- *= by an olivine
- s= side
- upper= Peter I
- 1A= Peter I, 1B= Peter II
- 5(i,j,f,d)= Aya

Phlogopite

ELEMENT	STANDARD
Na, Ti	Kaersuitite
Mg, Al, Si, Fe, K, F	Calbiotite
Ca	Rhodonite
Cr	Chromite
Mn	Willemite
Cl	Tugtupite
Ba	Sanadine
Ni	Fo_{90}

Oxides

ELEMENT	STANDARD
Mg	Ncchromite
Al	Chromite
Mn, Nb, Ti, Cr, Fe	Ilmenite

Apatite

ELEMENT	STANDARD
Sr	Strontianite
Mg, Fe	Osumilite
Si	Fayalite
Ca, P, F	Apatite
Mn	Willemite
Ce	$CePO_4$
La	$LaPO_4$
Nd	$NdPO_4$
Cl	Tugtupite
U	U-metal

Table Garnet. Peter (Pl) and K-L garnet compositions (wt. %).

No.	SiO2	TiO2	Al2O3	Cr2O3	FeO	MnO	MgO	CaO	NiO	Na2O	Total	Comment
10	40.91	0.52	17.74	7.13	6.44	0.28	19.98	5.99	0.04	0.04	99.06	Pl 1
11	41.16	0.46	17.60	6.98	6.50	0.25	19.91	5.94	0.03	0.02	98.85	Pl 1
12	40.61	0.57	17.83	7.09	6.48	0.28	20.17	5.80	0.01	0.02	98.85	Pl 1
13	40.08	0.53	17.76	6.98	6.48	0.27	20.03	5.99	0.01	0.02	98.14	Pl 1
14	40.46	0.45	17.77	7.12	6.58	0.26	19.89	5.88	0.01	0.01	98.42	Pl 2
15	40.68	0.46	17.63	7.07	6.45	0.27	20.19	5.94	0.07	0.04	98.78	Pl 2
16	40.65	0.55	17.27	7.05	6.55	0.26	20.17	6.07	0.02	0.03	98.61	Pl 2
17	35.71	0.13	21.36	0.02	28.83	12.94	0.60	0.33	0.08	0.05	100.05	Pl 3 r
18	35.39	0.12	21.30	0.05	28.72	13.05	0.55	0.33	0.09	0.04	99.63	Pl 3 r
19	35.28	0.11	21.27	0.03	28.50	13.04	0.56	0.33	0.10	0.02	99.24	Pl 3 c
20	35.63	0.12	21.51	0.03	28.73	13.01	0.54	0.32	0.07	0.04	100.01	Pl 3 c
21	37.06	0.11	22.57	0.04	33.75	0.27	6.35	0.88	0.09	0.00	101.12	Pl 4
22	37.37	0.12	22.57	0.05	33.62	0.25	6.38	0.89	0.06	0.00	101.32	Pl 4
23	37.32	0.13	22.44	0.05	33.46	0.26	6.30	0.93	0.06	0.01	100.94	Pl 5
24	37.36	0.12	22.52	0.06	33.43	0.27	6.34	0.90	0.07	0.02	101.08	Pl 6
25	37.45	0.12	22.91	0.05	33.75	0.25	6.32	0.95	0.08	0.00	101.87	Pl 7
26	37.65	0.11	21.24	0.05	33.49	0.28	6.40	0.88	0.07	0.01	100.19	Pl 8
27	37.34	0.12	22.41	0.09	33.67	0.26	6.47	0.91	0.05	0.02	101.34	Pl 8
28	37.90	0.05	22.79	0.09	30.10	0.63	7.85	1.65	0.07	0.00	101.12	Pl 9
29	40.48	0.54	22.66	1.06	9.78	0.48	17.81	7.08	0.01	0.05	99.94	KL2a 10
30	40.50	0.55	22.03	1.06	9.63	0.46	17.81	6.96	0.03	0.07	99.11	KL2a 10
31	38.21	0.06	23.32	0.08	28.58	0.26	9.94	1.18	0.04	0.01	101.67	KL2a11
32	38.27	0.09	23.33	0.06	28.46	0.29	9.91	1.06	0.06	0.01	101.53	KL2a11
33	36.54	0.15	22.39	0.07	38.79	0.20	2.89	1.22	0.10	0.00	102.35	KL2a 12
34	36.79	0.12	22.37	0.05	38.60	0.23	2.87	1.28	0.07	0.01	102.39	KL2a 12
35	39.73	0.03	19.64	0.01	35.35	0.16	2.61	0.90	0.00	0.00	98.42	KL2a 12
36	36.79	0.14	21.74	0.04	38.31	0.24	1.23	3.67	0.00	0.00	102.16	KL2a 13
37	36.75	0.12	21.94	0.02	39.05	0.26	1.23	3.51	0.01	0.02	102.91	KL2a 13
38	36.84	0.08	21.77	0.03	38.43	0.42	1.32	3.53	0.00	0.01	102.42	KL2a 13

Table Garnet. Structural formula based on 12 oxygens.

No.	Si	Ti	Al	Cr	Fe	Mn	Mg	Ca	Ni	Na	Total	Comment
10	2.988	0.029	1.527	0.412	0.393	0.017	2.175	0.469	0.002	0.006	8.017	Pl 1
11	3.009	0.025	1.516	0.403	0.398	0.015	2.170	0.466	0.002	0.002	8.007	Pl 1
12	2.972	0.031	1.538	0.410	0.397	0.017	2.201	0.455	0.000	0.003	8.024	Pl 1
13	2.958	0.029	1.545	0.407	0.400	0.017	2.204	0.474	0.001	0.003	8.038	Pl 1
14	2.976	0.025	1.541	0.414	0.405	0.016	2.181	0.463	0.001	0.002	8.023	Pl 2
15	2.981	0.025	1.523	0.409	0.395	0.017	2.205	0.466	0.004	0.005	8.031	Pl 2
16	2.987	0.030	1.496	0.409	0.402	0.016	2.209	0.478	0.001	0.004	8.033	Pl 2
17	2.938	0.008	2.072	0.001	1.984	0.902	0.073	0.029	0.006	0.007	8.021	Pl 3 r
18	2.928	0.008	2.078	0.003	1.987	0.915	0.067	0.029	0.006	0.006	8.027	Pl 3 r
19	2.929	0.007	2.081	0.002	1.979	0.917	0.070	0.029	0.007	0.003	8.024	Pl 3 c
20	2.933	0.008	2.086	0.002	1.977	0.907	0.067	0.029	0.004	0.007	8.019	Pl 3 c
21	2.903	0.007	2.084	0.002	2.211	0.018	0.742	0.074	0.006	0.001	8.047	Pl 4
22	2.917	0.007	2.077	0.003	2.194	0.017	0.742	0.075	0.004	0.000	8.036	Pl 4
23	2.923	0.008	2.071	0.003	2.192	0.017	0.736	0.078	0.004	0.002	8.033	Pl 5
24	2.921	0.007	2.076	0.004	2.186	0.018	0.739	0.075	0.005	0.003	8.033	Pl 6
25	2.908	0.007	2.096	0.003	2.191	0.016	0.731	0.079	0.005	0.001	8.036	Pl 7
26	2.975	0.007	1.978	0.003	2.213	0.019	0.754	0.074	0.005	0.002	8.029	Pl 8
27	2.916	0.007	2.063	0.006	2.199	0.017	0.753	0.076	0.003	0.003	8.044	Pl 8
28	2.925	0.003	2.073	0.006	1.943	0.041	0.903	0.136	0.005	0.000	8.033	Pl 9
29	2.929	0.029	1.932	0.061	0.592	0.030	1.921	0.549	0.000	0.007	8.049	KL2a 10
30	2.953	0.030	1.893	0.061	0.587	0.029	1.936	0.544	0.002	0.010	8.045	KL2a 10
31	2.901	0.003	2.086	0.005	1.814	0.017	1.124	0.096	0.002	0.002	8.051	KL2a11
32	2.907	0.005	2.088	0.004	1.808	0.018	1.122	0.086	0.003	0.001	8.043	KL2a11
33	2.898	0.009	2.094	0.005	2.573	0.014	0.342	0.104	0.006	0.000	8.044	KL2a 12
34	2.913	0.007	2.088	0.003	2.556	0.015	0.339	0.109	0.004	0.002	8.035	KL2a 12
35	3.204	0.002	1.867	0.000	2.384	0.011	0.314	0.078	0.000	0.000	7.860	KL2a 12
36	2.938	0.009	2.046	0.002	2.558	0.016	0.147	0.314	0.000	0.000	8.030	KL2a 13
37	2.921	0.007	2.055	0.001	2.595	0.018	0.146	0.299	0.001	0.003	8.046	KL2a 13
38	2.936	0.005	2.045	0.002	2.562	0.029	0.157	0.301	0.000	0.002	8.037	KL2a 13

Table Aya Amphibole. Aya amphibole compositions (wt. %).

No.	SiO2	TiO2	Al2O3	Cr2O3	FeO	MnO	MgO	CaO	BaO	Na2O	K2O	F	Cl	Total	Comment
4	56.22	0.04	0.65	0.00	8.23	0.18	19.92	13.01	0.01	0.10	0.05	0.13	0.01	98.48	5j1 1
5	55.61	0.07	1.12	0.02	8.38	0.20	19.98	12.51	0.02	0.17	0.07	0.18	0.00	98.26	5j1 2
6	54.59	0.07	1.40	0.00	8.36	0.18	19.40	12.90	0.08	0.21	0.07	0.16	0.00	97.35	5j1 3
7	55.86	0.05	0.45	0.00	7.59	0.16	19.99	13.19	0.06	0.07	0.13	0.15	0.00	97.64	5j1 4
8	55.39	0.04	0.78	0.09	7.96	0.17	19.58	12.96	0.03	0.12	0.08	0.14	0.00	97.27	5j1 5
9	55.90	0.06	0.77	0.02	7.07	0.16	20.42	13.09	0.02	0.11	0.06	0.17	0.00	97.78	5j1 6
10	56.27	0.08	0.49	0.05	7.14	0.15	20.09	13.11	0.03	0.09	0.16	0.15	0.00	97.75	5j2 1
11	56.27	0.08	0.41	0.06	5.98	0.14	20.79	13.45	0.03	0.10	0.21	0.19	0.00	97.60	5j2 2
12	56.33	0.02	0.26	0.00	5.19	0.14	21.32	13.27	0.00	0.05	0.15	0.13	0.00	96.82	5j2 3
13	55.90	0.05	0.86	0.00	7.35	0.14	20.31	13.13	0.03	0.15	0.05	0.17	0.00	98.06	5j2 4
14	56.78	0.08	0.34	0.01	4.19	0.12	22.22	13.27	0.00	0.07	0.13	0.14	0.01	97.30	5j2 5
15	55.78	0.06	0.69	0.00	8.16	0.21	19.64	13.12	0.00	0.10	0.04	0.11	0.01	97.85	5j3 1
16	55.41	0.04	0.84	0.02	8.30	0.20	19.48	12.99	0.00	0.11	0.06	0.14	0.00	97.54	5j3 2
17	55.24	0.06	1.06	0.00	8.23	0.23	19.47	12.88	0.04	0.16	0.05	0.10	0.01	97.48	5j3 3
18	55.87	0.06	0.75	0.00	8.08	0.17	19.80	12.89	0.06	0.12	0.06	0.13	0.00	97.93	5j3 4
19	55.48	0.05	0.96	0.00	8.34	0.19	19.70	12.91	0.03	0.15	0.06	0.18	0.01	97.95	5j3 5
20	55.29	0.03	1.09	0.02	7.79	0.21	19.69	13.13	0.02	0.15	0.08	0.14	0.00	97.57	5j4 1
21	55.69	0.04	1.19	0.02	7.10	0.19	20.35	12.85	0.05	0.24	0.05	0.16	0.00	97.85	5j4 2
22	55.71	0.13	0.57	0.02	6.46	0.24	20.72	13.15	0.00	0.11	0.18	0.16	0.01	97.40	5j4 3
23	55.36	0.08	1.02	0.06	8.03	0.21	19.92	12.81	0.07	0.15	0.09	0.16	0.00	97.89	5j4 4
24	55.50	0.05	0.67	0.10	7.45	0.20	20.06	12.89	0.00	0.11	0.05	0.13	0.01	97.16	5j4 5
25	55.56	0.04	0.60	0.03	4.94	0.16	21.52	13.13	0.00	0.11	0.05	0.16	0.00	96.23	5ia1 1
26	55.80	0.06	0.70	0.00	5.20	0.16	21.52	13.15	0.00	0.13	0.05	0.13	0.00	96.83	5ia1 2
27	55.55	0.09	0.78	0.02	5.04	0.18	21.70	12.89	0.00	0.15	0.04	0.15	0.00	96.52	5ia1 3
28	53.76	0.07	1.75	0.02	9.73	0.26	18.66	12.23	0.00	0.34	0.28	0.18	0.01	97.21	5ia2 1
29	53.46	0.10	1.91	0.05	9.89	0.29	18.24	12.26	0.02	0.37	0.25	0.18	0.02	96.95	5ia2 2
30	53.59	0.07	2.08	0.05	9.54	0.30	18.67	12.18	0.00	0.39	0.21	0.22	0.00	97.20	5ia2 3
31	55.77	0.03	0.85	0.07	5.28	0.17	21.50	13.26	0.00	0.17	0.06	0.12	0.00	97.23	5ia3 1
32	56.14	0.02	0.61	0.05	4.99	0.14	21.80	13.39	0.00	0.13	0.05	0.18	0.00	97.43	5ia3 2
33	56.70	0.04	0.46	0.02	4.60	0.14	21.82	13.51	0.00	0.10	0.06	0.13	0.00	97.51	5ia3 3
34	56.34	0.06	0.51	0.02	5.23	0.15	21.76	13.40	0.01	0.08	0.10	0.14	0.01	97.75	5ia4 1
35	54.23	0.08	0.37	0.07	4.83	0.15	21.29	14.16	0.00	0.11	0.11	0.12	0.02	95.46	5ia4 2

Table Aya Amphibole. (continued).

No.	SiO2	TiO2	Al2O3	Cr2O3	FeO	MnO	MgO	CaO	BaO	Na2O	K2O	F	Cl	Total	Comment
36	57.04	0.03	0.38	0.01	4.40	0.15	22.00	13.51	0.00	0.09	0.06	0.13	0.00	97.73	5ia4 3
37	56.35	0.05	0.45	0.10	5.26	0.20	21.76	13.11	0.01	0.09	0.05	0.17	0.00	97.53	5ia5 1
39	55.80	0.04	0.57	0.08	5.40	0.19	21.10	13.16	0.00	0.08	0.06	0.09	0.00	96.53	5ia5 3
40	56.18	0.04	0.29	0.27	3.73	0.16	22.96	13.13	0.00	0.13	0.17	0.17	0.00	97.15	5ia6 1
42	56.15	0.08	0.24	0.05	3.30	0.12	23.00	13.40	0.03	0.09	0.11	0.15	0.00	96.64	5ia6 3
43	55.52	0.10	0.39	0.05	4.97	0.16	21.46	13.01	0.00	0.08	0.13	0.13	0.01	95.95	5ib1 1
44	56.77	0.06	0.39	0.10	4.02	0.19	22.51	12.93	0.01	0.09	0.12	0.13	0.02	97.28	5ib1 2
45	56.72	0.05	0.32	0.11	3.53	0.18	22.42	13.12	0.00	0.14	0.18	0.16	0.01	96.86	5ib1 3
46	56.28	0.05	0.76	0.26	5.99	0.23	21.03	12.95	0.05	0.18	0.10	0.11	0.01	97.93	5ib1 4
47	55.72	0.10	1.49	0.12	6.55	0.24	20.51	12.79	0.00	0.27	0.15	0.17	0.01	98.05	5ib1 5
48	56.86	0.04	0.34	0.18	3.57	0.17	22.47	13.26	0.02	0.11	0.13	0.17	0.02	97.27	5ib2 1
49	56.68	0.01	0.27	0.06	5.22	0.16	21.54	13.24	0.01	0.07	0.12	0.16	0.00	97.47	5ib2 2
50	57.04	0.01	0.28	0.06	3.89	0.13	22.19	13.18	0.04	0.08	0.11	0.13	0.01	97.08	5ib2 3
51	56.95	0.05	0.36	0.06	4.17	0.19	22.33	13.35	0.00	0.12	0.09	0.13	0.01	97.74	5ib2 4
52	56.42	0.00	0.49	0.04	5.24	0.18	21.52	13.19	0.01	0.10	0.05	0.09	0.01	97.31	5ib2 5
53	56.34	0.00	0.54	0.05	5.25	0.20	21.27	13.07	0.00	0.11	0.06	0.12	0.01	96.96	5ib3 1
54	56.87	0.08	0.93	0.11	5.29	0.17	21.65	12.85	0.01	0.12	0.26	0.15	0.00	98.42	5ib3 2
55	56.71	0.10	0.41	0.06	3.86	0.18	22.21	13.28	0.00	0.07	0.11	0.13	0.01	97.07	5ib3 3
56	56.99	0.05	0.49	0.19	3.15	0.13	22.75	13.37	0.00	0.11	0.14	0.13	0.01	97.44	5ib3 4
57	56.86	0.06	0.46	0.09	4.82	0.16	21.72	13.09	0.01	0.09	0.12	0.15	0.00	97.57	5ib3 5
58	55.92	0.01	0.66	0.07	5.50	0.20	21.34	12.99	0.00	0.20	0.05	0.13	0.01	97.01	5ib4 1
59	56.57	0.05	0.58	0.07	5.75	0.22	21.62	12.90	0.00	0.12	0.06	0.14	0.02	98.03	5ib4 2
60	56.02	0.04	1.08	0.04	5.89	0.19	20.98	13.14	0.00	0.13	0.03	0.14	0.02	97.63	5ib4 3
61	55.46	0.03	1.16	0.07	5.86	0.21	20.97	12.86	0.01	0.17	0.06	0.13	0.02	96.95	5ib4 4
62	55.70	0.01	0.72	0.13	5.78	0.24	21.19	12.80	0.05	0.15	0.05	0.11	0.01	96.87	5ib4 5

Table Aya Amphibole. Structural formula based on 23 oxygens.

No.	Si	Ti	Al	Cr	Fe	Mn	Mg	Ca	Ba	Na	K	F	Cl	Total	Comment
4	7.863	0.005	0.107	0.000	0.962	0.022	4.152	1.949	0.001	0.028	0.009	0.057	0.001	15.155	5j1 1
5	7.803	0.008	0.184	0.002	0.984	0.024	4.179	1.881	0.001	0.047	0.013	0.080	0.000	15.206	5j1 2
6	7.755	0.008	0.234	0.000	0.994	0.021	4.107	1.963	0.005	0.058	0.012	0.072	0.000	15.227	5j1 3
7	7.873	0.006	0.075	0.000	0.895	0.020	4.200	1.991	0.003	0.020	0.023	0.068	0.000	15.173	5j1 4
8	7.846	0.005	0.129	0.010	0.943	0.020	4.135	1.967	0.002	0.032	0.015	0.062	0.000	15.166	5j1 5
9	7.843	0.006	0.127	0.002	0.829	0.019	4.271	1.968	0.001	0.031	0.011	0.077	0.000	15.185	5j1 6
10	7.897	0.008	0.081	0.006	0.838	0.018	4.204	1.971	0.002	0.024	0.029	0.068	0.000	15.146	5j2 1
11	7.882	0.008	0.068	0.006	0.700	0.017	4.341	2.018	0.001	0.027	0.037	0.082	0.000	15.187	5j2 2
12	7.911	0.002	0.044	0.000	0.610	0.017	4.463	1.997	0.000	0.014	0.026	0.060	0.000	15.144	5j2 3
13	7.830	0.006	0.142	0.000	0.861	0.017	4.242	1.970	0.002	0.040	0.009	0.074	0.001	15.192	5j2 4
14	7.896	0.009	0.056	0.001	0.487	0.015	4.607	1.977	0.000	0.018	0.023	0.061	0.003	15.152	5j2 5
15	7.856	0.006	0.114	0.000	0.961	0.025	4.122	1.980	0.000	0.027	0.008	0.047	0.002	15.148	5j3 1
16	7.837	0.005	0.141	0.002	0.981	0.024	4.108	1.969	0.000	0.031	0.011	0.064	0.000	15.172	5j3 2
17	7.817	0.007	0.176	0.000	0.974	0.028	4.108	1.952	0.002	0.043	0.010	0.046	0.002	15.163	5j3 3
18	7.856	0.007	0.124	0.000	0.950	0.020	4.151	1.942	0.003	0.032	0.011	0.060	0.000	15.156	5j3 4
19	7.817	0.005	0.159	0.000	0.982	0.022	4.137	1.949	0.002	0.041	0.011	0.081	0.002	15.207	5j3 5
20	7.807	0.003	0.182	0.003	0.920	0.025	4.145	1.986	0.001	0.041	0.014	0.061	0.000	15.186	5j4 1
21	7.808	0.004	0.197	0.002	0.833	0.023	4.253	1.931	0.003	0.065	0.008	0.072	0.000	15.197	5j4 2
22	7.839	0.014	0.094	0.002	0.760	0.029	4.346	1.983	0.000	0.031	0.032	0.073	0.002	15.205	5j4 3
23	7.800	0.008	0.169	0.006	0.946	0.026	4.183	1.934	0.004	0.042	0.016	0.073	0.000	15.207	5j4 4
24	7.850	0.005	0.112	0.011	0.881	0.024	4.229	1.954	0.000	0.031	0.009	0.060	0.002	15.166	5j4 5
25	7.849	0.004	0.100	0.003	0.584	0.019	4.531	1.987	0.000	0.031	0.008	0.070	0.000	15.186	5ia1 1
26	7.839	0.006	0.116	0.000	0.611	0.019	4.506	1.979	0.000	0.036	0.008	0.059	0.000	15.179	5ia1 2
27	7.823	0.009	0.129	0.002	0.594	0.021	4.555	1.945	0.000	0.041	0.008	0.066	0.000	15.193	5ia1 3
28	7.703	0.007	0.296	0.003	1.166	0.031	3.985	1.877	0.000	0.095	0.051	0.082	0.002	15.298	5ia2 1
29	7.691	0.010	0.324	0.006	1.190	0.036	3.911	1.890	0.001	0.102	0.046	0.083	0.005	15.295	5ia2 2
30	7.672	0.008	0.351	0.006	1.142	0.037	3.985	1.868	0.000	0.109	0.039	0.098	0.000	15.314	5ia2 3
31	7.812	0.004	0.141	0.008	0.618	0.020	4.488	1.990	0.000	0.045	0.011	0.051	0.000	15.189	5ia3 1
32	7.837	0.002	0.101	0.006	0.582	0.017	4.538	2.004	0.000	0.035	0.009	0.080	0.000	15.210	5ia3 2
33	7.885	0.004	0.075	0.002	0.535	0.017	4.523	2.013	0.000	0.027	0.011	0.056	0.000	15.148	5ia3 3
34	7.847	0.006	0.084	0.002	0.609	0.018	4.517	2.000	0.001	0.022	0.018	0.061	0.001	15.187	5ia4 1
35	7.769	0.008	0.062	0.008	0.579	0.018	4.546	2.173	0.000	0.031	0.020	0.052	0.004	15.270	5ia4 2

Table Aya Amphibole. (continued).

No.	Si	Ti	Al	Cr	Fe	Mn	Mg	Ca	Ba	Na	K	F	Cl	Total	Comment
36	7.903	0.003	0.062	0.001	0.510	0.017	4.544	2.006	0.000	0.024	0.011	0.056	0.000	15.136	5ia4 3
37	7.862	0.006	0.074	0.011	0.613	0.023	4.525	1.960	0.000	0.025	0.009	0.077	0.001	15.184	5ia5 1
39	7.869	0.004	0.095	0.009	0.636	0.022	4.436	1.988	0.000	0.021	0.011	0.042	0.001	15.134	5ia5 3
40	7.830	0.004	0.048	0.030	0.435	0.018	4.769	1.961	0.000	0.035	0.030	0.076	0.000	15.236	5ia6 1
42	7.847	0.008	0.040	0.006	0.385	0.014	4.792	2.006	0.002	0.025	0.019	0.065	0.001	15.209	5ia6 3
43	7.867	0.011	0.064	0.005	0.589	0.019	4.533	1.976	0.000	0.023	0.023	0.057	0.002	15.169	5ib1 1
44	7.888	0.006	0.063	0.011	0.468	0.022	4.661	1.925	0.001	0.025	0.021	0.058	0.005	15.155	5ib1 2
45	7.905	0.006	0.052	0.012	0.411	0.021	4.657	1.959	0.000	0.037	0.032	0.069	0.001	15.162	5ib1 3
46	7.847	0.005	0.124	0.029	0.698	0.027	4.371	1.935	0.003	0.047	0.018	0.050	0.003	15.157	5ib1 4
47	7.782	0.010	0.246	0.014	0.765	0.028	4.270	1.915	0.000	0.072	0.027	0.076	0.002	15.207	5ib1 5
48	7.895	0.004	0.056	0.020	0.414	0.020	4.651	1.973	0.001	0.030	0.023	0.076	0.004	15.169	5ib2 1
49	7.907	0.001	0.045	0.007	0.609	0.019	4.480	1.979	0.001	0.018	0.022	0.070	0.000	15.156	5ib2 2
50	7.933	0.001	0.046	0.007	0.452	0.016	4.601	1.964	0.002	0.021	0.019	0.058	0.001	15.119	5ib2 3
51	7.886	0.005	0.058	0.007	0.482	0.022	4.610	1.981	0.000	0.032	0.017	0.057	0.001	15.159	5ib2 4
52	7.882	0.000	0.081	0.004	0.612	0.022	4.480	1.974	0.001	0.028	0.008	0.041	0.002	15.136	5ib2 5
53	7.897	0.000	0.089	0.006	0.615	0.023	4.444	1.963	0.000	0.029	0.011	0.054	0.003	15.133	5ib3 1
54	7.855	0.008	0.151	0.012	0.611	0.020	4.457	1.902	0.000	0.031	0.046	0.065	0.000	15.158	5ib3 2
55	7.894	0.010	0.068	0.007	0.450	0.021	4.610	1.981	0.000	0.018	0.020	0.056	0.002	15.136	5ib3 3
56	7.881	0.005	0.079	0.020	0.364	0.015	4.691	1.981	0.000	0.030	0.025	0.057	0.001	15.149	5ib3 4
57	7.904	0.006	0.075	0.010	0.560	0.019	4.501	1.949	0.001	0.023	0.021	0.068	0.001	15.138	5ib3 5
58	7.851	0.001	0.109	0.008	0.645	0.023	4.467	1.955	0.000	0.056	0.009	0.056	0.003	15.182	5ib4 1
59	7.861	0.005	0.095	0.008	0.668	0.026	4.478	1.920	0.000	0.033	0.010	0.062	0.005	15.171	5ib4 2
60	7.826	0.004	0.178	0.004	0.688	0.023	4.369	1.966	0.000	0.036	0.006	0.063	0.005	15.167	5ib4 3
61	7.805	0.004	0.192	0.008	0.690	0.025	4.400	1.939	0.001	0.046	0.010	0.059	0.004	15.182	5ib4 4
62	7.843	0.001	0.119	0.014	0.680	0.028	4.447	1.930	0.003	0.040	0.009	0.049	0.002	15.167	5ib4 5

Table Meliadine Phlogopite. Peter and K-L phlogopite compositions (wt. %).

No.	SiO2	TiO2	Al2O3	Cr2O3	FeO	MnO	MgO	BaO	CaO	NiO	Na2O	K2O	F	Cl	Total	Comment
154	38.12	2.39	13.69	0.07	7.62	0.05	21.11	0.38	0.07	0.04	0.23	9.30	0.16	0.02	93.16	1A-2 1-1
155	35.11	2.13	15.04	0.10	13.29	0.06	16.26	0.09	0.10	0.06	0.36	8.71	0.13	0.03	91.39	1A-2 1-2
156	37.84	1.68	13.76	0.08	8.72	0.05	19.02	0.29	1.59	0.04	0.40	8.91	0.15	0.03	92.49	1A-2 1-3
157	36.09	2.05	16.97	0.00	5.17	0.05	22.40	1.46	0.06	0.00	0.13	9.85	0.08	0.01	94.27	1A-2 1-4
158	35.02	1.41	14.26	0.00	5.68	0.08	21.07	1.19	2.82	0.01	0.20	9.62	0.21	0.01	91.50	1A-2 2c 1
159	37.97	1.45	13.55	0.00	6.59	0.07	23.19	0.61	0.18	0.02	0.27	10.24	0.20	0.01	94.25	1A-2 2c 2
163	36.41	1.39	14.52	0.00	5.89	0.07	22.20	1.16	0.74	0.04	0.16	9.69	0.17	0.00	92.37	1A-2 2r 3
164	36.27	3.24	14.92	0.04	19.77	0.27	11.02	0.12	0.05	0.05	0.24	9.95	0.40	0.02	96.18	1A-2 3r 1
165	36.62	3.39	15.02	0.01	19.81	0.27	11.14	0.15	0.04	0.07	0.29	10.20	0.46	0.05	97.32	1A-2 3r 2
167	36.69	1.19	12.75	0.00	5.99	0.11	22.04	0.82	1.57	0.03	0.17	9.36	0.41	0.02	90.97	1A-2 3c 2
209	36.98	3.08	14.49	0.06	6.65	0.04	21.38	0.50	0.17	0.00	0.24	9.65	0.22	0.00	93.37	1A-2 9r 1
210	36.65	3.04	14.41	0.09	6.76	0.03	20.87	0.48	0.10	0.02	0.25	9.99	0.15	0.00	92.78	1A-2 9r 2
214	36.49	2.68	16.59	0.00	5.42	0.03	22.28	1.28	0.08	0.00	0.19	9.69	0.13	0.00	94.80	1A-2 10r 3
215	35.98	2.56	16.00	0.00	5.55	0.05	21.44	1.00	0.10	0.00	0.24	9.75	0.11	0.00	92.72	1A-2 10c 1
216	35.75	2.38	16.82	0.00	5.32	0.02	22.36	1.52	0.08	0.00	0.20	9.69	0.05	0.00	94.19	1A-2 10c 2
217	35.14	1.96	16.49	0.00	5.53	0.05	21.92	1.37	0.12	0.00	0.18	9.38	0.19	0.00	92.23	1A-2 10c 3
218	36.58	1.98	15.86	0.00	5.79	0.06	21.85	1.39	0.17	0.00	0.19	9.43	0.30	0.04	93.49	1A-2 11c 1
219	35.75	2.16	16.89	0.01	5.54	0.10	21.79	1.55	0.15	0.02	0.18	9.93	0.15	0.01	94.15	1A-2 11c 2
221	36.16	1.97	15.50	0.01	7.22	0.08	21.67	1.47	0.22	0.06	0.17	8.99	0.19	0.00	93.64	1A-2 11r 1
223	35.58	1.40	14.70	0.00	7.91	0.08	22.10	0.94	0.34	0.02	0.15	9.10	0.14	0.02	92.40	1A-2 11r 3
228	37.09	3.09	14.78	0.13	7.02	0.06	20.94	0.53	0.11	0.01	0.25	10.11	0.13	0.02	94.22	1A-2 12c 1
229	30.08	0.39	11.48	0.05	19.24	0.10	22.98	0.43	0.31	0.00	0.10	2.49	0.40	0.03	87.88	1A-2 12c 2
230	36.48	2.04	17.21	0.00	5.64	0.05	22.25	1.68	0.13	0.00	0.17	10.15	0.15	0.00	95.88	1A-2 12c 3
249	35.76	2.30	16.42	0.05	5.34	0.08	21.72	1.51	0.10	0.00	0.27	9.97	0.26	0.00	93.66	1A-2 16r 1
250	34.99	2.33	17.60	0.06	5.45	0.06	21.54	2.13	0.10	0.00	0.20	9.79	0.16	0.01	94.36	1A-2 16r 2
251	37.15	2.32	15.45	0.15	8.66	0.07	19.73	0.35	0.05	0.02	0.29	10.46	0.18	0.01	94.80	1A-2 16r 3
252	38.26	2.12	15.50	0.10	7.59	0.06	21.13	0.30	0.06	0.00	0.23	10.26	0.43	0.02	95.86	1A-2 16c 1
254	37.89	1.97	14.88	0.13	8.43	0.08	20.62	0.29	0.11	0.03	0.36	9.95	0.35	0.02	94.95	1A-2 16c 3
256	36.24	1.88	16.87	0.02	5.61	0.06	22.48	1.35	0.13	0.00	0.22	10.16	0.23	0.00	95.13	1A-2 17c 2
257	35.63	1.98	16.59	0.04	5.76	0.07	22.20	1.24	0.15	0.00	0.15	10.04	0.18	0.01	93.96	1A-2 17c 3
258	37.33	2.81	14.27	0.12	6.79	0.04	20.94	0.48	0.09	0.04	0.20	10.11	0.13	0.01	93.29	1A-2 17r 1
259	36.31	1.46	16.56	0.00	5.80	0.07	22.55	1.65	0.19	0.01	0.10	10.23	0.14	0.00	95.03	1A-2 17r 2
263	35.57	2.42	15.84	0.00	5.96	0.06	21.41	1.28	0.10	0.01	0.28	9.65	0.17	0.04	92.72	1A-2 18r 3
264	36.35	2.25	16.54	0.00	5.56	0.05	21.82	1.24	0.03	0.02	0.18	10.27	0.14	0.02	94.38	1A-2 18c 1
265	36.30	2.44	16.00	0.03	6.12	0.06	21.61	1.18	0.07	0.02	0.21	9.92	0.11	0.01	94.01	1A-2 18c 2
266	36.34	2.49	15.20	0.01	6.85	0.05	21.03	0.63	0.27	0.00	0.30	10.03	0.15	0.04	93.31	1A-2 18c 3
267	36.42	2.38	16.62	0.00	5.87	0.05	21.84	1.26	0.05	0.00	0.20	9.97	0.12	0.01	94.74	1A-2 19c 1

Table Meliadine Phlogopite. (continued).

No.	SiO2	TiO2	Al2O3	Cr2O3	FeO	MnO	MgO	BaO	CaO	NiO	Na2O	K2O	F	Cl	Total	Comment
268	37.63	2.78	14.50	0.14	6.96	0.03	21.43	0.50	0.03	0.02	0.24	10.31	0.19	0.01	94.67	1A-2 19c 2
271	36.93	2.72	13.42	0.03	8.72	0.04	20.92	0.36	0.22	0.02	0.24	8.96	0.18	0.02	92.70	1A-2 19r 2
272	35.07	1.99	16.40	0.01	6.17	0.06	20.98	1.44	0.12	0.02	0.26	9.48	0.12	0.01	92.06	1A-2 19r 3
285	35.10	1.79	16.89	0.00	5.50	0.06	21.77	1.60	0.14	0.03	0.16	9.82	0.20	0.02	92.98	1A-2 22r 1
286	35.18	1.77	16.63	0.00	5.53	0.06	21.81	1.48	0.18	0.00	0.15	10.07	0.17	0.02	92.96	1A-2 22r 2
287	35.39	1.57	16.02	0.00	6.34	0.08	21.80	1.61	0.34	0.00	0.19	9.61	0.27	0.03	93.12	1A-2 22r 3
291	35.55	1.82	16.72	0.00	5.38	0.03	21.85	1.56	0.08	0.00	0.20	10.06	0.19	0.02	93.36	1A-2 23c 1
292	35.35	1.85	16.93	0.00	5.50	0.07	21.77	1.48	0.11	0.02	0.17	9.83	0.19	0.03	93.21	1A-2 23c 2
295	35.18	1.73	16.08	0.02	11.46	0.06	17.22	0.06	0.08	0.06	0.43	9.65	0.20	0.03	92.14	1A-2 23r 2
296	35.94	1.46	14.68	0.00	5.52	0.04	21.93	1.31	0.19	0.00	0.12	9.88	0.26	0.02	91.22	1A-2 23r 3
297	36.17	1.63	17.11	0.00	5.42	0.06	22.57	1.48	0.15	0.01	0.18	9.95	0.19	0.01	94.84	1A-2 24r 1
298	36.35	3.96	15.42	0.00	19.01	0.13	11.28	0.23	0.07	0.05	0.25	9.73	0.41	0.10	96.78	1A-2 24r 2
300	35.91	1.94	16.91	0.00	5.32	0.03	22.00	1.32	0.04	0.01	0.20	9.82	0.08	0.00	93.56	1A-2 24c 1
301	36.44	4.12	15.61	0.00	18.68	0.12	11.52	0.17	0.02	0.03	0.31	10.07	0.45	0.09	97.41	1A-2 24c 2
312	37.49	3.09	14.59	0.12	6.95	0.02	21.51	0.44	0.11	0.07	0.23	9.92	0.10	0.02	94.61	1A-2 26c 1
314	37.32	3.00	14.95	0.06	7.04	0.01	21.61	0.50	0.09	0.10	0.22	9.89	0.07	0.01	94.83	1A-2 26c 3
318	35.49	2.08	16.99	0.00	5.36	0.05	21.94	1.82	0.15	0.01	0.13	9.49	0.03	0.00	93.54	1A-2 27r 1
323	35.16	1.85	16.82	0.00	5.54	0.08	22.03	1.25	0.19	0.00	0.18	9.65	0.08	0.00	92.80	1b 1r 3
324	33.83	2.23	17.06	0.02	5.52	0.07	21.33	2.02	0.27	0.04	0.16	9.72	0.00	0.01	92.27	1b 1c 1
328	32.21	2.04	16.43	0.00	5.51	0.10	20.99	1.59	0.10	0.00	0.19	9.93	0.07	0.01	89.14	1b 2c 2
332	35.46	2.20	17.09	0.02	5.73	0.07	22.09	1.75	0.08	0.02	0.17	9.77	0.04	0.01	94.49	1b 3r 1
333	36.10	1.93	16.23	0.00	5.92	0.06	22.15	1.46	0.10	0.00	0.17	9.70	0.04	0.00	93.84	1b 3r 2
334	35.69	2.08	16.59	0.00	5.79	0.08	21.68	1.68	0.16	0.00	0.14	9.96	0.05	0.01	93.88	1b 3r 3
335	35.21	1.88	16.09	0.00	5.40	0.07	21.79	1.56	0.10	0.04	0.17	9.34	0.08	0.01	91.68	1b 3c 1
336	35.56	2.10	16.95	0.02	5.52	0.06	21.79	1.66	0.08	0.00	0.18	9.54	0.00	0.02	93.47	1b 3c 2
337	35.94	1.98	16.01	0.00	5.92	0.08	22.21	1.31	0.08	0.01	0.19	9.89	0.02	0.02	93.62	1b 3c 3
338	35.48	2.19	17.13	0.00	5.24	0.04	22.24	1.71	0.07	0.01	0.13	9.50	0.00	0.00	93.73	1b 3c 4
339	35.93	2.13	17.10	0.04	21.19	0.12	9.57	0.25	0.00	0.11	0.37	9.91	0.11	0.07	96.84	1b 4c 1
340	35.87	2.18	16.38	0.02	21.74	0.12	10.15	0.26	0.08	0.11	0.36	9.18	0.18	0.07	96.61	1b 4c 2
341	38.07	1.15	16.35	0.00	5.29	0.04	22.22	0.62	0.04	0.04	0.21	9.53	0.25	0.00	93.72	1b 4c 3
342	36.60	2.01	16.45	0.00	5.78	0.06	21.70	1.50	0.07	0.03	0.18	9.79	0.03	0.01	94.18	1b 4r 1
344	35.41	1.99	16.27	0.00	5.86	0.05	21.39	1.39	0.13	0.05	0.20	9.53	0.00	0.00	92.28	1b 4r 3
345	35.20	1.74	16.35	0.00	5.56	0.04	21.58	1.63	0.17	0.01	0.18	9.86	0.02	0.00	92.33	1b 5r 1
346	34.75	1.99	16.71	0.00	5.43	0.05	21.65	1.94	0.14	0.03	0.18	9.96	0.04	0.01	92.84	1b 5r 2
347	34.61	2.13	16.63	0.00	5.19	0.06	21.39	2.10	0.12	0.04	0.15	9.66	0.12	0.01	92.14	1b 5r 3
348	34.88	1.85	16.36	0.00	5.47	0.04	21.64	1.52	0.06	0.03	0.16	9.86	0.04	0.00	91.89	1b 5c 1
349	34.65	1.88	16.39	0.00	5.47	0.06	21.44	1.55	0.08	0.02	0.15	9.71	0.01	0.00	91.41	1b 5c 2
350	35.06	2.02	16.51	0.00	5.56	0.04	21.60	1.80	0.04	0.02	0.18	9.81	0.08	0.00	92.68	1b 5c 3

Table Meliadine Phlogopite. (continued).

No.	SiO2	TiO2	Al2O3	Cr2O3	FeO	MnO	MgO	BaO	CaO	NiO	Na2O	K2O	F	Cl	Total	Comment
351	32.94	2.22	15.53	0.00	4.96	0.04	20.23	1.48	3.84	0.07	0.24	8.98	0.10	0.01	90.59	Ib 6c 1
352	35.12	2.26	16.00	0.00	5.26	0.03	21.04	1.52	1.26	0.05	0.23	9.23	0.14	0.00	92.07	Ib 6c 2
353	35.80	2.29	17.29	0.00	5.09	0.02	21.69	1.68	0.17	0.03	0.20	9.61	0.01	0.00	93.87	Ib 6c 3
355	35.18	1.70	15.67	0.00	5.40	0.04	21.68	1.44	0.21	0.02	0.21	9.33	0.02	0.01	90.90	Ib 6r 2
356	35.78	1.78	16.79	0.00	5.37	0.05	22.08	1.48	0.30	0.05	0.14	10.21	0.00	0.01	94.01	Ib 6r 3
357	36.26	1.58	16.06	0.00	5.41	0.06	22.13	1.29	0.37	0.01	0.14	9.99	0.01	0.00	93.30	Ib 7r 1
358	36.42	1.67	15.86	0.00	6.04	0.06	21.70	1.32	0.27	0.04	0.21	9.49	0.13	0.00	93.17	Ib 7r 2
359	35.16	1.91	16.36	0.00	5.38	0.03	21.28	1.34	0.13	0.01	0.25	9.35	0.04	0.00	91.23	Ib 7r 3
360	35.54	2.00	17.05	0.00	5.85	0.05	21.89	1.61	0.16	0.04	0.19	9.57	0.04	0.00	93.97	Ib 7c 1
361	35.28	2.19	17.05	0.00	5.63	0.09	21.89	1.78	0.18	0.02	0.21	9.75	0.01	0.00	94.07	Ib 7c 2
362	35.80	2.05	17.04	0.00	5.44	0.06	22.07	1.66	0.30	0.03	0.14	9.73	0.08	0.00	94.37	Ib 7c 3
363	35.46	2.19	17.31	0.00	5.71	0.09	21.93	1.88	0.05	0.04	0.20	9.77	0.05	0.00	94.66	Ib 8c 1
364	35.17	2.19	16.67	0.00	6.23	0.06	21.79	1.69	0.08	0.02	0.27	9.15	0.07	0.01	93.35	Ib 8c 2
365	35.63	2.16	17.37	0.00	5.63	0.07	21.72	1.82	0.05	0.01	0.19	9.66	0.07	0.00	94.34	Ib 8c 3
367	35.83	2.02	17.03	0.00	5.46	0.06	21.84	1.56	0.05	0.00	0.24	9.84	0.06	0.00	93.96	Ib 8r 2
368	36.42	1.80	16.83	0.00	5.40	0.08	22.31	1.49	0.04	0.00	0.21	9.94	0.04	0.00	94.54	Ib 8r 3
369	36.09	2.22	17.13	0.00	5.26	0.06	22.00	1.45	0.25	0.03	0.18	9.37	0.01	0.00	94.05	Ib 9r 1
370	36.34	2.23	17.17	0.00	5.15	0.06	22.50	1.60	0.28	0.00	0.20	9.73	0.04	0.00	95.29	Ib 9r 2
371	37.32	2.06	15.50	0.00	5.10	0.05	21.89	1.39	0.47	0.02	0.24	9.87	0.33	0.00	94.08	Ib 9r 3
372	36.36	1.75	16.60	0.00	5.47	0.06	22.52	1.29	0.08	0.03	0.18	9.74	0.02	0.00	94.09	Ib 9c 1
373	35.35	2.04	16.99	0.00	5.63	0.09	22.01	1.61	0.06	0.04	0.18	9.68	0.05	0.00	93.70	Ib 9c 2
374	35.74	2.11	17.03	0.00	5.49	0.06	22.22	1.85	0.07	0.02	0.19	9.69	0.02	0.01	94.48	Ib 9c 3
375	35.55	2.15	16.95	0.00	5.44	0.06	21.62	1.63	0.06	0.00	0.19	9.54	0.03	0.00	93.19	Ib 10c 1
376	35.39	2.08	16.92	0.00	5.38	0.06	21.85	1.72	0.07	0.01	0.22	9.70	0.02	0.00	93.40	Ib 10c 2
377	35.37	2.13	17.08	0.00	5.24	0.05	21.81	1.77	0.07	0.00	0.17	9.76	0.05	0.00	93.48	Ib 10c 3
378	35.53	2.12	17.30	0.00	5.68	0.06	22.02	1.81	0.11	0.00	0.12	9.64	0.06	0.02	94.43	Ib 10r 1
379	36.87	1.80	15.46	0.00	6.13	0.07	22.49	0.98	0.13	0.00	0.17	10.20	0.06	0.01	94.33	Ib 10r 2
380	35.68	2.04	16.80	0.00	6.05	0.08	22.13	1.46	0.14	0.03	0.17	9.88	0.14	0.01	94.53	Ib 10r 3
381	35.98	1.86	16.94	0.00	5.39	0.06	22.33	1.50	0.18	0.00	0.16	10.08	0.06	0.00	94.52	Ib 11r 1
382	35.76	2.13	16.86	0.00	5.79	0.06	22.16	1.94	0.29	0.01	0.16	9.86	0.16	0.02	95.13	Ib 11c 1
383	35.73	2.04	16.93	0.00	5.76	0.06	22.30	1.73	0.16	0.00	0.17	9.71	0.12	0.02	94.68	Ib 12c 1
384	36.75	1.76	16.36	0.00	5.64	0.09	22.46	1.33	0.19	0.00	0.14	10.18	0.09	0.00	94.96	Ib 12r 1
385	38.05	1.68	12.96	0.00	7.61	0.06	22.70	0.66	0.32	0.00	0.22	10.08	0.15	0.00	94.42	Ib 13
387	38.57	1.61	12.96	0.00	7.80	0.08	23.21	0.61	0.18	0.01	0.22	10.10	0.21	0.01	95.47	Ib 15
388	36.94	1.39	15.75	0.00	6.02	0.07	22.88	1.12	0.58	0.03	0.12	10.25	0.13	0.01	95.23	Ib 16
389	36.59	1.58	16.46	0.00	5.89	0.08	22.66	1.31	0.28	0.00	0.14	10.17	0.14	0.01	95.24	Ib 17
390	36.62	1.40	15.46	0.00	5.79	0.08	22.50	0.93	0.39	0.00	0.35	10.03	0.09	0.30	93.84	Ib 18
391	36.73	1.82	16.04	0.00	6.07	0.06	22.44	1.41	0.27	0.02	0.15	10.23	0.12	0.00	95.29	Ib 19

Table Meliadine Phlogopite. (continued).

No.	SiO2	TiO2	Al2O3	Cr2O3	FeO	MnO	MgO	BaO	CaO	NiO	Na2O	K2O	F	Cl	Total	Comment
392	36.28	1.58	16.17	0.00	5.72	0.07	22.77	1.26	0.22	0.00	0.16	10.12	0.13	0.00	94.41	1b 20
393	36.20	1.55	16.51	0.00	5.73	0.07	22.47	1.40	0.46	0.02	0.15	10.21	0.13	0.01	94.83	1b 21
394	35.24	1.93	17.12	0.00	5.68	0.08	22.02	1.76	0.39	0.00	0.15	9.92	0.10	0.02	94.36	1b 22
395	34.86	2.31	17.44	0.02	5.41	0.04	21.84	2.11	0.28	0.00	0.19	9.90	0.10	0.02	94.48	1b 23
396	36.13	1.68	15.70	0.00	5.89	0.06	22.61	1.46	0.29	0.00	0.16	10.08	0.22	0.02	94.18	1b 24
398	49.01	1.11	0.78	0.02	5.10	0.05	20.27	0.04	2.72	0.00	0.94	9.83	4.87	0.00	92.68	1b 25r 2
399	34.95	2.28	16.51	0.09	5.29	0.06	21.74	1.44	0.11	0.00	0.25	9.64	0.00	0.01	92.35	1b 25r 3
400	35.45	2.29	16.78	0.08	5.31	0.06	22.05	1.60	0.06	0.01	0.21	9.93	0.00	0.00	93.82	1b 25c 1
401	35.32	2.34	16.89	0.14	5.37	0.05	21.69	1.72	0.11	0.01	0.21	9.77	0.00	0.01	93.62	1b 25c 2
402	35.63	2.33	16.95	0.08	5.40	0.04	21.89	1.78	0.06	0.01	0.19	9.93	0.00	0.00	94.28	1b 25c 3
409	34.79	2.46	16.15	0.04	5.29	0.08	21.16	1.43	0.09	0.01	0.31	9.88	0.00	0.09	91.75	1b 32
411	35.38	1.66	16.09	0.07	5.76	0.06	21.90	1.39	0.18	0.01	0.29	10.15	0.00	0.12	93.03	1b 34
414	46.58	0.45	3.92	0.11	5.69	0.08	23.02	0.32	0.31	0.01	0.73	9.77	2.31	0.03	92.33	1b 37
415	40.50	1.26	13.67	0.12	5.75	0.08	23.74	1.04	0.47	0.03	0.41	8.42	0.59	0.04	95.85	1b 38
416	35.47	1.68	15.79	0.05	5.88	0.08	22.13	1.63	0.19	0.01	0.23	9.73	0.00	0.03	92.90	1b 39
519	36.49	3.55	14.50	0.01	19.62	0.23	11.95	0.12	0.06	0.00	0.26	9.60	0.30	0.08	96.62	upper 1c 1 z
520	36.35	3.40	14.28	0.00	19.56	0.24	11.68	0.06	0.11	0.00	0.27	9.74	0.30	0.08	95.92	upper 1c 2 z
521	35.86	3.23	14.53	0.00	20.45	0.26	12.28	0.07	0.06	0.03	0.25	8.97	0.32	0.07	96.21	upper 1c 3 z
522	37.01	1.63	15.58	0.00	6.24	0.07	22.86	0.90	0.12	0.00	0.19	10.04	0.09	0.00	94.70	upper 1r 1 z
523	33.98	1.80	15.49	0.00	11.26	0.06	22.00	0.91	0.07	0.00	0.21	7.64	0.14	0.01	93.50	upper 1r 2 z
524	36.28	2.35	15.37	0.00	7.55	0.07	21.93	0.88	0.11	0.00	0.26	9.51	0.08	0.00	94.35	upper 1r 3 z
525	36.16	2.11	16.79	0.00	5.50	0.05	22.31	1.42	0.09	0.00	0.16	9.87	0.05	0.01	94.49	upper 2r 1
526	37.83	3.09	15.26	0.00	6.55	0.01	22.02	0.41	0.11	0.00	0.23	9.87	0.10	0.00	95.43	upper 2r 2
527	36.14	2.43	16.73	0.00	5.14	0.06	22.31	1.24	0.08	0.00	0.19	9.97	0.07	0.00	94.31	upper 2r 3
528	35.84	2.25	17.16	0.00	5.15	0.04	22.32	1.49	0.05	0.00	0.17	9.87	0.04	0.01	94.37	upper 2c 1
529	37.55	3.21	14.62	0.03	6.52	0.05	21.57	0.38	0.03	0.00	0.25	10.39	0.10	0.00	94.67	upper 2c 2
530	37.66	3.19	14.63	0.07	6.57	0.04	21.94	0.39	0.04	0.00	0.21	10.08	0.07	0.00	94.86	upper 2c 3
531	37.84	1.44	13.78	0.00	17.27	0.17	16.12	0.19	0.03	0.00	1.00	9.08	0.36	0.01	97.14	upper 3c 1 z
532	37.66	1.32	13.29	0.00	16.51	0.18	15.81	0.11	0.02	0.00	0.90	9.21	0.32	0.01	95.20	upper 3c 2 z
533	37.22	1.37	14.26	0.00	17.28	0.16	15.04	0.13	0.11	0.02	0.89	9.12	0.29	0.01	95.78	upper 3c 3 z
534	35.95	1.83	16.92	0.00	5.16	0.05	22.39	1.28	0.09	0.00	0.15	9.86	0.04	0.00	93.70	upper 3r 1 z
535	36.07	2.01	17.12	0.00	5.01	0.02	22.50	1.36	0.06	0.00	0.23	9.90	0.04	0.00	94.30	upper 3r 2 z
536	36.03	2.14	16.99	0.00	5.00	0.04	22.25	1.43	0.12	0.00	0.21	9.95	0.04	0.00	94.18	upper 3r 3 z
537	36.05	2.30	16.25	0.00	5.53	0.05	22.29	1.27	0.13	0.00	0.18	9.72	0.06	0.00	93.78	upper 4r 1
538	36.38	1.95	16.78	0.00	5.46	0.05	22.69	1.18	0.17	0.00	0.25	10.03	0.12	0.00	95.00	upper 4r 2
539	36.97	1.78	16.51	0.00	5.47	0.07	23.09	1.25	0.14	0.02	0.15	10.17	0.10	0.00	95.67	upper 4r 3
540	37.48	3.28	14.38	0.14	6.58	0.03	21.59	0.47	0.10	0.04	0.27	10.08	0.10	0.03	94.52	upper 4c 1
541	37.90	3.16	14.68	0.14	6.55	0.05	21.97	0.45	0.08	0.03	0.27	10.32	0.11	0.01	95.68	upper 4c 2

Table Melladine Phlogopite. (continued).

No.	SiO2	TiO2	Al2O3	Cr2O3	FeO	MnO	MgO	BaO	CaO	NiO	Na2O	K2O	F	Cl	Total	Comment
542	35.70	1.87	16.23	0.00	5.41	0.06	22.23	0.99	0.13	0.03	0.22	9.95	0.07	0.02	92.88	upper 4c 3
543	36.78	2.61	16.16	0.00	5.55	0.05	22.21	1.01	0.09	0.03	0.20	10.26	0.07	0.01	94.99	upper 5c 1
544	36.14	2.02	16.85	0.00	5.28	0.06	22.20	1.41	0.10	0.01	0.15	10.29	0.04	0.01	94.53	upper 5c 2
545	37.56	3.11	14.38	0.09	6.72	0.03	21.56	0.48	0.10	0.06	0.22	10.48	0.06	0.01	94.82	upper 5c 3
546	37.10	1.63	15.41	0.00	5.92	0.07	22.72	0.92	0.13	0.00	0.17	10.40	0.10	0.01	94.55	upper 5r 1
547	37.63	1.28	14.97	0.00	5.92	0.05	23.15	0.68	0.12	0.01	0.14	10.62	0.08	0.01	94.63	upper 5r 2
548	36.37	1.97	16.69	0.00	5.38	0.08	22.44	1.39	0.15	0.00	0.19	10.08	0.07	0.01	94.79	upper 5r 3
549	37.22	3.11	14.56	0.13	6.67	0.03	21.55	0.45	0.11	0.05	0.20	10.38	0.06	0.01	94.52	upper 6r 1
550	38.12	3.06	14.36	0.09	6.59	0.03	21.98	0.49	0.09	0.04	0.22	10.42	0.11	0.01	95.55	upper 6r 2
551	35.75	2.15	16.97	0.00	5.27	0.06	22.23	1.51	0.14	0.02	0.15	10.11	0.08	0.01	94.41	upper 6r 3
552	37.80	3.14	14.52	0.12	6.65	0.03	21.84	0.43	0.06	0.05	0.21	10.35	0.08	0.01	95.28	upper 6c 1
553	37.90	3.04	14.46	0.15	6.50	0.02	21.74	0.40	0.08	0.02	0.20	10.61	0.07	0.01	95.18	upper 6c 2
554	36.21	1.85	16.77	0.00	5.30	0.08	22.48	1.33	0.11	0.00	0.14	10.24	0.08	0.02	94.56	upper 6c 3
555	38.46	1.63	13.38	0.04	18.13	0.49	12.79	0.23	0.13	0.02	0.31	10.20	2.35	0.06	97.20	upper 7c 1 brown
556	38.81	1.62	13.43	0.06	17.68	0.50	12.58	0.27	0.07	0.04	0.06	10.40	2.54	0.05	97.04	upper 7c 2 brown
557	38.37	1.70	13.55	0.07	18.22	0.51	12.97	0.21	0.07	0.00	0.16	10.49	2.54	0.04	97.81	upper 7c 3 brown
558	38.30	1.65	13.17	0.06	18.05	0.52	12.78	0.20	0.12	0.06	0.36	9.99	2.35	0.04	96.64	upper 7c 4 brown
559	38.48	1.69	13.37	0.00	18.12	0.47	12.69	0.23	0.16	0.01	0.19	10.30	2.41	0.03	97.11	upper 7r 1 brown
560	38.44	1.58	13.08	0.03	18.34	0.54	13.06	0.20	0.18	0.00	0.30	10.43	2.40	0.03	97.57	upper 7r 2 brown
561	37.99	1.64	13.16	0.02	18.29	0.47	12.63	0.19	0.13	0.02	0.54	10.23	2.33	0.04	96.69	upper 7r 3 brown
562	38.50	1.69	13.39	0.04	18.30	0.45	12.63	0.17	0.10	0.00	0.23	10.30	2.34	0.03	97.17	upper 7r 4 brown
563	38.07	1.68	12.96	0.02	7.09	0.03	23.21	0.57	0.12	0.00	0.23	10.40	0.01	0.00	94.39	upper 8r 1 z
564	38.00	1.76	14.09	0.00	6.48	0.02	23.30	0.66	0.12	0.00	0.22	10.20	0.04	0.00	94.87	upper 8r 2 z
565	36.27	1.85	16.18	0.00	5.58	0.03	22.30	1.24	0.10	0.00	0.21	10.26	0.00	0.00	94.02	upper 8r 3 z
566	36.46	3.34	14.76	0.04	19.55	0.22	11.16	0.07	0.06	0.02	0.25	10.22	0.19	0.01	96.26	upper 8c 1 z
567	36.44	3.45	14.77	0.07	19.78	0.24	11.25	0.08	0.07	0.02	0.22	10.26	0.22	0.04	96.80	upper 8c 2 z
568	36.51	3.40	14.82	0.09	19.44	0.20	11.25	0.04	0.03	0.04	0.23	10.49	0.23	0.03	96.68	upper 8c 3 z
569	36.62	3.37	14.66	0.04	19.77	0.21	11.08	0.10	0.05	0.02	0.26	10.38	0.20	0.03	96.70	upper 9c 1 z
570	36.67	3.38	14.70	0.03	19.48	0.21	11.08	0.06	0.05	0.00	0.29	10.27	0.20	0.01	96.35	upper 9c 2 z
571	36.14	3.27	14.57	0.05	19.44	0.24	11.09	0.04	0.07	0.00	0.31	10.17	0.18	0.03	95.52	upper 9c 3 z
572	35.58	2.25	16.80	0.01	5.89	0.03	22.30	1.68	0.13	0.00	0.19	9.80	0.01	0.01	94.69	upper 9r 1 z
573	35.16	2.25	16.36	0.00	6.14	0.03	21.61	1.56	0.17	0.00	0.23	9.73	0.02	0.01	93.27	upper 9r 2 z
574	36.35	1.79	15.85	0.00	5.75	0.05	22.47	1.10	0.09	0.00	0.22	10.25	0.01	0.01	93.94	upper 9r 3 z
575	36.00	2.01	16.60	0.00	5.35	0.01	22.34	1.35	0.15	0.00	0.25	10.00	0.00	0.00	94.05	upper 10r 1
576	36.78	1.66	16.22	0.00	5.66	0.06	22.63	1.36	0.08	0.00	0.22	10.29	0.00	0.00	94.96	upper 10r 2
577	35.94	2.34	16.82	0.00	6.01	0.03	22.38	1.45	0.12	0.00	0.30	9.82	0.00	0.00	95.20	upper 10r 3
578	35.87	1.99	16.55	0.01	5.38	0.01	22.30	1.35	0.07	0.00	0.25	10.08	0.00	0.00	93.85	upper 10c 1
579	35.85	2.09	17.09	0.00	5.50	0.07	22.29	1.40	0.09	0.00	0.15	9.94	0.06	0.01	94.51	upper 10c 2

Table Meliadine Phlogopite. (continued).

No.	SiO2	TiO2	Al2O3	Cr2O3	FeO	MnO	MgO	BaO	CaO	NiO	Na2O	K2O	F	Cl	Total	Comment
580	36.09	2.48	14.06	1.23	12.81	0.10	18.58	0.78	0.09	0.13	0.54	8.86	0.09	0.00	95.81	upper 10c 3
581	37.75	2.70	14.94	0.00	7.63	0.07	21.50	0.51	0.08	0.00	0.30	10.43	0.09	0.00	95.97	upper 11c 1
582	36.39	2.16	16.70	0.00	5.44	0.05	22.38	1.51	0.06	0.00	0.21	10.22	0.06	0.00	95.15	upper 11c 2
583	36.85	2.50	16.17	0.00	5.73	0.06	22.30	1.07	0.05	0.00	0.22	10.37	0.07	0.00	95.35	upper 11c 3
584	36.47	1.82	16.48	0.00	5.87	0.05	22.71	1.30	0.13	0.00	0.16	10.18	0.08	0.00	95.23	upper 11r 1
585	37.68	1.26	15.51	0.00	5.97	0.08	23.44	1.00	0.10	0.00	0.17	10.34	0.09	0.01	95.62	upper 11r 2
586	35.97	2.00	16.70	0.00	5.65	0.06	22.34	1.39	0.10	0.00	0.17	10.39	0.08	0.00	94.80	upper 11r 3
587	36.61	2.74	16.03	0.00	5.81	0.06	21.97	0.94	0.15	0.00	0.24	10.43	0.06	0.00	95.02	upper 12r 1
588	36.28	2.57	16.33	0.00	5.55	0.07	22.28	1.08	0.10	0.00	0.18	10.00	0.03	0.01	94.45	upper 12r 2
589	35.81	1.98	17.03	0.00	5.41	0.06	22.58	1.43	0.17	0.00	0.17	10.27	0.07	0.01	94.94	upper 12r 3
590	36.18	2.62	16.19	0.00	5.47	0.07	22.24	1.09	0.08	0.00	0.18	10.13	0.10	0.00	94.31	upper 12c 1
591	37.50	2.52	14.81	0.00	7.87	0.04	20.93	0.40	0.09	0.00	0.32	10.28	0.12	0.00	94.83	upper 12c 2
592	36.07	2.20	16.93	0.00	5.25	0.04	22.43	1.47	0.08	0.00	0.15	10.26	0.09	0.00	94.92	upper 12c 3
593	36.02	2.31	17.15	0.00	5.32	0.04	22.35	1.68	0.03	0.00	0.17	10.37	0.06	0.00	95.46	upper 13c 1
594	36.12	2.10	17.17	0.00	5.37	0.06	22.49	1.54	0.06	0.00	0.17	10.33	0.05	0.00	95.45	upper 13c 2
595	36.10	2.27	17.28	0.00	5.30	0.05	22.46	1.67	0.06	0.00	0.15	9.89	0.06	0.00	95.26	upper 13c 3
596	36.09	2.15	17.16	0.00	5.13	0.07	22.35	1.57	0.10	0.00	0.19	10.11	0.10	0.00	94.98	upper 13r 1
597	37.54	1.43	14.64	0.00	6.56	0.07	22.82	0.86	0.19	0.00	0.19	9.56	0.14	0.01	93.95	upper 13r 2
598	36.27	1.78	16.85	0.00	5.38	0.05	22.76	1.43	0.13	0.00	0.18	10.31	0.09	0.00	95.19	upper 13r 3
599	27.31	1.34	12.27	0.04	24.18	0.03	18.76	0.23	0.40	0.00	0.07	2.00	0.16	0.00	86.74	upper 14 around ol
600	30.89	1.48	13.82	0.00	16.51	0.05	20.72	0.67	0.21	0.00	0.17	4.53	0.16	0.00	89.15	upper 14 around ol
601	35.67	1.93	16.48	0.05	6.07	0.05	21.02	1.45	0.12	0.00	0.21	9.71	0.02	0.00	92.76	upper 14 around ol
602	37.58	3.11	14.36	0.11	6.67	0.03	19.87	0.47	0.04	0.00	0.23	10.50	0.05	0.01	92.98	upper 15c 1
603	37.13	3.01	14.59	0.07	6.57	0.02	20.22	0.47	0.03	0.00	0.27	10.30	0.05	0.00	92.69	upper 15c 2
604	37.08	3.10	14.48	0.12	6.71	0.03	20.35	0.39	0.05	0.00	0.25	10.51	0.03	0.00	93.10	upper 15c 3
605	35.73	2.24	17.05	0.00	5.24	0.06	20.99	1.54	0.04	0.00	0.18	10.11	0.00	0.00	93.18	upper 15r 1
606	36.04	2.08	16.62	0.00	5.37	0.03	21.06	1.45	0.10	0.00	0.28	10.19	0.02	0.00	93.24	upper 15r 2
607	36.95	3.12	14.63	0.13	6.73	0.03	20.12	0.51	0.07	0.00	0.29	10.53	0.03	0.00	93.12	upper 15r 3
608	34.78	2.49	17.13	0.00	5.39	0.07	20.31	1.80	0.10	0.00	0.18	9.77	0.02	0.00	92.03	upper 16r 1
609	35.59	2.21	16.89	0.00	5.16	0.04	20.74	1.44	0.10	0.00	0.17	10.27	0.00	0.00	92.60	upper 16r 2
610	37.29	3.24	14.58	0.12	7.06	0.05	20.17	0.39	0.11	0.00	0.22	10.58	0.02	0.00	93.82	upper 16r 3
611	37.44	2.96	14.67	0.11	6.80	0.03	20.27	0.43	0.02	0.00	0.23	10.44	0.00	0.00	93.40	upper 16c 1
612	37.54	3.03	14.43	0.16	6.69	0.04	20.36	0.41	0.04	0.00	0.21	10.52	0.02	0.00	93.43	upper 16c 3
616	36.23	1.56	16.24	0.00	5.51	0.06	21.32	1.15	0.13	0.00	0.21	10.20	0.02	0.00	92.61	upper 17r 1
617	37.93	3.06	14.78	0.15	6.71	0.04	20.61	0.39	0.13	0.00	0.23	10.28	0.05	0.00	94.33	upper 17r 2
618	35.43	1.80	16.27	0.00	5.51	0.05	20.69	1.43	0.20	0.00	0.19	10.02	0.00	0.02	91.59	upper 17r 3
619	36.04	2.50	17.06	0.00	5.52	0.06	22.34	1.61	0.12	0.01	0.11	10.22	0.05	0.01	95.63	upper 18r 1
620	36.12	2.13	16.99	0.03	5.60	0.07	22.60	1.78	0.16	0.02	0.18	10.14	0.08	0.00	95.87	upper 18r 2

Table Melladine Phlogopite. (continued).

No.	SiO2	TiO2	Al2O3	Cr2O3	FeO	MnO	MgO	BaO	CaO	NiO	Na2O	K2O	F	Cl	Total	Comment
621	35.50	2.42	17.09	0.01	5.49	0.06	22.21	1.69	0.16	0.00	0.20	10.09	0.02	0.02	94.94	upper 18r 3
622	36.14	2.67	16.20	0.04	5.55	0.05	22.14	1.07	0.12	0.01	0.17	10.28	0.06	0.01	94.46	upper 18c 1
623	37.58	3.02	14.61	0.17	6.66	0.05	21.72	0.50	0.11	0.05	0.22	10.42	0.06	0.01	95.15	upper 18c 2
624	35.56	2.19	16.86	0.00	5.12	0.06	22.46	1.49	0.12	0.00	0.19	10.21	0.05	0.00	94.29	upper 18c 3
628	37.56	1.77	14.23	0.04	6.34	0.05	22.96	0.58	0.17	0.01	0.22	10.25	0.07	0.00	94.21	upper 19r 1 z
629	37.02	1.62	15.70	0.03	5.70	0.05	22.91	1.10	0.09	0.00	0.16	10.29	0.07	0.00	94.71	upper 19r 2 z
630	36.40	1.91	16.84	0.01	5.53	0.05	22.74	1.31	0.05	0.00	0.18	9.91	0.07	0.00	94.95	upper 19r 3 z
631	34.95	2.43	17.46	0.00	5.43	0.08	22.27	1.96	0.13	0.00	0.18	9.82	0.08	0.00	94.76	upper 20r 1
632	36.21	2.57	16.53	0.10	5.44	0.03	22.35	1.26	0.07	0.00	0.18	9.96	0.05	0.00	94.72	upper 20r 2
633	36.18	2.18	16.69	0.01	5.39	0.05	22.57	1.46	0.10	0.00	0.18	10.02	0.01	0.00	94.84	upper 20r 3
634	38.06	3.22	14.05	0.15	7.11	0.03	22.03	0.50	0.06	0.02	0.23	10.23	0.09	0.00	95.72	upper 20c 1
635	37.62	3.08	14.23	0.15	6.87	0.05	21.80	0.49	0.06	0.03	0.22	9.87	0.05	0.00	94.49	upper 20c 2
636	37.72	3.01	14.56	0.12	6.34	0.05	21.91	0.43	0.08	0.01	0.18	10.35	0.09	0.00	94.81	upper 20c 3
637	35.99	2.49	16.54	0.00	5.42	0.06	22.33	1.07	0.10	0.00	0.19	10.03	0.08	0.00	94.26	upper 21c 1
638	37.85	2.99	14.27	0.22	6.62	0.05	21.77	0.52	0.09	0.05	0.18	10.38	0.11	0.00	95.05	upper 21c 2
639	36.10	2.03	16.80	0.00	5.40	0.07	22.63	1.37	0.10	0.05	0.16	9.54	0.08	0.00	94.30	upper 21c 3
640	35.92	1.37	15.42	0.00	5.37	0.06	22.23	1.20	0.30	0.04	0.23	9.43	0.10	0.02	91.65	upper 21r 1
641	36.24	1.81	16.56	0.00	5.41	0.07	22.74	1.36	0.14	0.05	0.21	9.82	0.12	0.00	94.47	upper 21r 2
642	36.15	1.65	16.08	0.00	5.53	0.08	22.57	1.25	0.18	0.06	0.19	9.71	0.14	0.02	93.53	upper 21r 3
643	37.01	2.78	16.12	0.00	5.79	0.04	22.47	0.98	0.14	0.04	0.22	9.92	0.11	0.00	95.55	upper 22r 1
644	37.76	3.13	14.97	0.13	6.91	0.05	21.92	0.47	0.12	0.05	0.28	9.92	0.10	0.00	95.77	upper 22r 2
645	35.32	2.48	17.16	0.00	5.46	0.07	21.78	1.91	0.13	0.04	0.23	9.44	0.07	0.02	94.07	upper 22r 3
646	37.86	3.10	14.60	0.11	6.62	0.03	21.87	0.44	0.08	0.07	0.29	9.81	0.13	0.01	94.96	upper 22c 1
647	36.16	2.24	16.85	0.00	5.37	0.04	22.41	1.41	0.14	0.04	0.26	9.42	0.07	0.00	94.38	upper 22c 2
648	37.35	3.11	14.46	0.15	6.85	0.04	21.87	0.50	0.09	0.07	0.27	9.83	0.12	0.02	94.65	upper 22c 3
649	37.92	4.10	13.90	0.00	7.22	0.06	21.15	0.50	0.10	0.06	0.27	10.00	0.11	0.00	95.34	upper 23c 1
650	37.19	3.13	14.71	0.21	6.84	0.06	21.58	0.49	0.11	0.08	0.25	10.02	0.11	0.03	94.75	upper 23c 2
651	37.46	3.10	14.42	0.19	7.00	0.06	21.74	0.43	0.09	0.06	0.23	10.10	0.13	0.01	94.96	upper 23c 3
652	35.70	2.35	17.14	0.01	5.33	0.07	22.29	1.64	0.17	0.03	0.19	9.74	0.08	0.01	94.69	upper 23r 1
653	36.06	2.03	16.81	0.00	5.14	0.06	22.17	1.36	0.20	0.01	0.15	9.78	0.08	0.01	93.81	upper 23r 2
654	36.29	2.74	16.21	0.02	5.57	0.05	22.01	1.17	0.18	0.07	0.20	9.87	0.08	0.01	94.43	upper 23r 3
655	37.56	2.92	14.22	0.12	6.98	0.06	21.72	0.35	0.07	0.05	0.23	10.28	0.10	0.01	94.62	upper 24r 1
656	37.78	2.97	14.53	0.04	7.15	0.08	21.57	0.44	0.11	0.06	0.29	9.79	0.13	0.02	94.88	upper 24r 2
657	37.61	1.66	14.42	0.00	6.22	0.08	23.02	0.68	0.14	0.03	0.21	9.74	0.16	0.02	93.90	upper 24r 3
658	37.48	3.08	14.24	0.17	6.97	0.03	21.72	0.40	0.08	0.07	0.28	9.75	0.10	0.01	94.34	upper 24c 1
659	37.51	3.10	14.66	0.20	8.09	0.06	21.19	0.39	0.04	0.06	0.33	9.88	0.14	0.01	95.60	upper 24c 2
660	37.09	2.94	14.04	0.14	7.02	0.05	21.24	0.35	0.04	0.04	0.31	9.99	0.17	0.01	93.36	upper 24c 3
661	31.76	1.90	12.55	0.43	18.70	0.10	19.19	0.42	0.19	0.11	0.32	5.27	0.20	0.01	91.07	upper 25c 1 large

Table Meliadine Phlogopite. (continued).

No.	SiO2	TiO2	Al2O3	Cr2O3	FeO	MnO	MgO	BaO	CaO	NiO	Na2O	K2O	F	Cl	Total	Comment
662	37.95	1.82	13.73	0.69	9.67	0.08	20.10	0.61	0.00	0.16	0.58	9.79	0.20	0.00	95.30	upper 25c 2 large
663	36.96	2.33	14.15	0.50	11.29	0.09	18.84	1.08	0.00	0.15	0.55	9.57	0.17	0.01	95.61	upper 25c 3 large
664	37.15	2.75	14.06	0.27	11.71	0.12	18.45	1.18	0.03	0.12	0.57	9.53	0.21	0.01	96.06	upper 25c 4 large
665	37.57	1.83	14.47	0.33	11.02	0.09	19.12	0.56	0.00	0.08	0.44	10.02	0.23	0.03	95.69	upper 25c 5 large
666	37.12	2.82	15.32	0.06	6.09	0.05	21.68	0.63	0.01	0.02	0.20	10.30	0.18	0.01	94.41	upper 25r 1 large
667	37.26	3.24	14.52	0.14	6.87	0.07	21.56	0.46	0.02	0.08	0.20	10.43	0.13	0.02	94.94	upper 25r 2 large
668	36.57	3.13	14.25	0.18	6.92	0.05	21.35	0.57	0.02	0.05	0.23	10.25	0.15	0.02	93.66	upper 25r 3 large
669	37.73	3.06	14.46	0.12	6.75	0.06	21.59	0.42	0.01	0.08	0.26	10.28	0.15	0.03	94.93	upper 25r 4 large
670	35.99	2.45	16.35	0.04	5.37	0.07	22.20	1.29	0.04	0.00	0.21	10.08	0.12	0.01	94.16	upper 25r 5 large
671	29.98	1.96	12.31	0.18	29.64	0.35	12.84	0.07	0.19	0.04	0.18	4.26	0.34	0.04	92.22	upper 26c 1 z
672	35.47	2.43	14.53	0.16	21.84	0.38	11.35	0.10	0.14	0.06	0.28	9.37	0.35	0.04	96.35	upper 26c 2 z
673	35.63	2.30	14.34	0.15	22.04	0.39	11.61	0.09	0.15	0.08	0.27	9.35	0.37	0.04	96.64	upper 26c 3 z
674	35.97	1.50	15.80	0.02	6.33	0.07	22.55	1.12	0.22	0.00	0.21	9.79	0.13	0.01	93.67	upper 26r 1 z
675	36.11	1.39	15.29	0.01	7.43	0.11	22.83	0.91	0.14	0.00	0.21	9.68	0.18	0.00	94.20	upper 26r 2 z
676	35.40	1.39	15.21	0.00	8.78	0.11	22.98	0.86	0.17	0.03	0.17	8.73	0.18	0.01	93.94	upper 26r 3 z
679	36.48	1.82	16.82	0.02	5.24	0.06	22.58	1.41	0.31	0.00	0.12	9.27	0.08	0.01	94.18	upper 28 1
680	36.20	2.05	17.00	0.00	5.39	0.07	22.34	1.68	0.29	0.00	0.12	9.31	0.08	0.00	94.49	upper 28 2
681	35.80	1.94	16.02	0.00	6.73	0.06	22.06	1.34	0.31	0.00	0.15	9.11	0.10	0.01	93.58	upper 29 1
682	33.98	1.78	15.30	0.00	8.89	0.06	21.58	1.11	0.32	0.00	0.15	7.83	0.11	0.01	91.05	upper 29 2
683	35.55	1.60	15.32	0.00	7.96	0.08	22.33	1.21	0.41	0.00	0.14	8.51	0.11	0.00	93.17	upper 30 1
684	36.88	1.67	15.76	0.00	6.13	0.08	22.70	1.46	0.32	0.00	0.14	9.63	0.10	0.00	94.82	upper 30 2
685	36.81	1.52	15.95	0.01	5.95	0.05	22.60	1.49	0.32	0.00	0.18	9.38	0.15	0.00	94.35	upper 31 1
686	36.58	1.67	16.42	0.00	5.69	0.05	22.44	1.39	0.30	0.00	0.18	9.24	0.10	0.01	94.01	upper 31 2
687	34.95	2.36	16.39	0.00	7.25	0.07	21.76	1.31	0.33	0.00	0.23	8.58	0.10	0.00	93.29	upper 32 1
688	33.88	1.71	15.06	0.00	10.50	0.05	22.21	0.90	0.34	0.00	0.21	7.11	0.12	0.00	92.04	upper 32 2
689	35.52	1.59	13.54	0.00	11.45	0.08	22.66	0.54	0.23	0.00	0.18	7.59	0.16	0.00	93.49	upper 33 1
690	35.34	1.50	15.21	0.00	8.29	0.06	22.54	0.95	0.33	0.00	0.23	8.46	0.09	0.01	92.97	upper 33 2
693	39.51	0.72	10.21	0.00	8.46	0.11	24.08	0.58	0.40	0.00	0.09	9.80	0.29	0.01	94.13	upper 35 1
694	37.64	0.86	14.22	0.00	5.28	0.09	23.73	1.17	0.32	0.00	0.12	9.64	0.18	0.00	93.17	upper 35 2
695	37.75	0.94	14.99	0.00	5.67	0.08	23.54	1.00	0.30	0.00	0.10	9.77	0.15	0.00	94.23	upper 35 3
696	36.83	2.12	14.90	0.00	7.14	0.09	22.43	1.01	0.33	0.00	0.15	9.73	0.12	0.00	94.78	upper 33 1
697	36.61	2.01	15.46	0.00	6.53	0.07	22.59	1.23	0.35	0.00	0.16	9.47	0.09	0.01	94.53	upper 33 2
698	37.34	1.47	15.38	0.00	5.69	0.06	23.02	0.89	0.26	0.02	0.13	9.86	0.12	0.00	94.17	upper 34 1
699	36.46	1.90	16.06	0.02	5.67	0.08	22.62	1.29	0.24	0.01	0.11	10.08	0.11	0.03	94.61	upper 34 2
700	36.58	1.78	16.11	0.01	5.31	0.10	22.71	1.31	0.33	0.00	0.11	10.30	0.15	0.02	94.74	upper 34 3
701	0.00	1.16	0.00	0.04	5.28	0.08	0.00	0.89	0.39	0.02	0.00	9.58	0.13	0.02	17.54	upper 35 1
702	0.00	1.33	0.00	0.00	5.49	0.07	0.00	0.83	0.38	0.00	0.00	9.45	0.14	0.01	17.65	upper 35 2
703	36.84	1.53	15.13	0.01	6.07	0.07	22.96	0.96	0.35	0.00	0.19	10.33	0.13	0.01	94.52	upper 36 1
704	35.81	1.89	15.97	0.03	5.56	0.08	22.26	1.21	0.39	0.03	0.23	9.89	0.09	0.02	93.40	upper 36 2
705	36.09	1.96	15.67	0.00	5.79	0.08	22.45	1.35	0.38	0.03	0.19	10.05	0.10	0.02	94.11	upper 36 3
706	35.78	1.37	13.85	0.04	9.04	0.08	22.81	0.70	0.42	0.00	0.22	8.75	0.15	0.02	93.17	upper 37 1
707	35.32	1.20	14.16	0.00	8.92	0.09	22.70	0.86	0.41	0.02	0.19	8.55	0.19	0.01	92.55	upper 37 2

Table Meliadine Phlogopite. (continued).

No.	SiO2	TiO2	Al2O3	Cr2O3	FeO	MnO	MgO	BaO	CaO	NiO	Na2O	K2O	F	Cl	Total	Comment
708	37.30	1.26	15.00	0.03	5.83	0.09	23.00	1.01	0.28	0.04	0.13	10.41	0.15	0.01	94.49	upper 38 1
709	38.50	1.25	12.20	0.03	7.13	0.09	23.24	0.45	0.30	0.02	0.17	10.36	0.17	0.03	93.83	upper 38 2
710	36.42	1.56	14.95	0.05	6.55	0.09	23.00	1.22	0.43	0.04	0.14	9.99	0.16	0.02	94.55	upper 39 1
711	36.85	1.18	14.14	0.03	7.16	0.08	23.69	1.16	0.42	0.00	0.11	9.35	0.26	0.02	94.34	upper 39 2
712	36.50	4.36	14.83	0.04	18.53	0.16	11.42	0.24	0.04	0.06	0.28	10.56	0.39	0.09	97.31	upper 40 core 1 z
713	36.55	4.55	14.69	0.07	18.13	0.17	11.40	0.19	0.03	0.06	0.22	10.46	0.38	0.10	96.82	upper 40 core 2 z
714	35.78	3.01	15.71	0.02	6.22	0.07	21.83	1.26	0.12	0.02	0.20	10.27	0.11	0.02	94.59	upper 40 rim 1 z
715	36.23	2.13	16.65	0.00	5.46	0.05	22.57	1.48	0.10	0.03	0.20	10.19	0.12	0.02	95.18	upper 40 rim 2 z
716	36.58	1.69	15.32	0.01	5.95	0.08	22.62	1.06	0.09	0.01	0.22	10.42	0.16	0.02	94.17	upper 40 rim 3 z

Table Meliadine Phlogopite. Structural formula based on 11 oxygens.

No.	Si	Ti	Al	Cr	Fe	Mn	Mg	Ba	Ca	Ni	Na	K	F	Cl	Total	Comment
154	2.825	0.133	1.196	0.004	0.472	0.003	2.332	0.011	0.006	0.002	0.034	0.880	0.036	0.003	7.937	1A-2 1-1
155	2.727	0.125	1.377	0.006	0.863	0.004	1.883	0.003	0.009	0.004	0.054	0.863	0.032	0.003	7.951	1A-2 1-2
156	2.846	0.095	1.220	0.005	0.548	0.003	2.133	0.008	0.128	0.003	0.059	0.855	0.035	0.004	7.942	1A-2 1-3
157	2.646	0.113	1.466	0.000	0.317	0.003	2.448	0.042	0.005	0.000	0.018	0.922	0.019	0.001	7.998	1A-2 1-4
158	2.686	0.082	1.289	0.000	0.364	0.006	2.408	0.036	0.232	0.000	0.029	0.942	0.052	0.002	8.127	1A-2 2c 1
159	2.795	0.080	1.175	0.000	0.406	0.005	2.544	0.018	0.014	0.001	0.038	0.961	0.046	0.001	8.084	1A-2 2c 2
163	2.738	0.079	1.287	0.000	0.371	0.004	2.489	0.034	0.059	0.002	0.023	0.930	0.040	0.000	8.056	1A-2 2r 3
164	2.775	0.186	1.346	0.003	1.265	0.017	1.257	0.004	0.004	0.003	0.036	0.972	0.098	0.003	7.968	1A-2 3r 1
165	2.773	0.193	1,341	0.001	1.254	0.018	1.257	0.005	0.003	0.004	0.042	0.985	0.109	0.006	7.992	1A-2 3r 2
167	2.806	0.068	1.149	0.000	0.383	0.007	2.513	0.025	0.129	0.002	0.025	0.914	0.099	0.002	8.121	1A-2 3c 2
209	2.739	0.172	1.265	0.004	0.412	0.003	2.360	0.014	0.013	0.000	0.035	0.912	0.051	0.000	7.979	1A-2 9r 1
210	2.739	0.171	1.270	0.005	0.423	0.002	2.326	0.014	0.008	0.001	0.037	0.952	0.036	0.000	7.983	1A-2 9r 2
214	2.657	0.147	1.424	0.000	0.330	0.002	2.419	0.036	0.007	0.000	0.026	0.900	0.031	0.000	7.978	1A-2 10r 3
215	2.680	0.144	1.404	0.000	0.346	0.003	2.380	0.029	0.008	0.000	0.034	0.926	0.026	0.000	7.980	1A-2 10c 1
216	2.627	0.131	1.457	0.000	0.327	0.001	2.450	0.044	0.007	0.000	0.029	0.909	0.011	0.000	7.993	1A-2 10c 2
217	2.638	0.110	1.459	0.000	0.347	0.003	2.453	0.040	0.009	0.000	0.026	0.899	0.044	0.000	8.029	1A-2 10c 3
218	2.708	0.110	1.385	0.000	0.358	0.004	2.411	0.040	0.013	0.000	0.028	0.891	0.069	0.005	8.023	1A-2 11c 1
219	2.638	0.120	1.468	0.001	0.342	0.006	2.396	0.045	0.012	0.001	0.025	0.935	0.035	0.002	8.024	1A-2 11c 2
221	2.690	0.110	1.359	0.001	0.449	0.005	2.403	0.043	0.017	0.004	0.024	0.853	0.045	0.000	8.004	1A-2 11r 1
223	2.689	0.079	1.309	0.000	0.500	0.005	2.490	0.028	0.028	0.001	0.021	0.877	0.033	0.003	8.063	1A-2 11r 3
228	2.733	0.171	1.283	0.008	0.433	0.004	2.300	0.015	0.009	0.001	0.036	0.951	0.030	0.003	7.976	1A-2 12c 1
229	2.475	0.024	1.113	0.003	1.324	0.007	2.818	0.014	0.027	0.000	0.016	0.261	0.105	0.004	8.190	1A-2 12c 2
230	2.643	0.111	1.470	0.000	0.342	0.003	2.403	0.048	0.010	0.000	0.024	0.938	0.035	0.000	8.026	1A-2 12c 3
249	2.653	0.128	1.436	0.003	0.331	0.005	2.401	0.044	0.008	0.000	0.038	0.943	0.060	0.000	8.051	1A-2 16r 1
250	2.587	0.130	1.534	0.004	0.337	0.004	2.374	0.062	0.008	0.000	0.028	0.923	0.038	0.001	8.030	1A-2 16r 2
251	2.740	0.128	1.343	0.009	0.534	0.004	2.169	0.010	0.004	0.001	0.042	0.984	0.043	0.001	8.013	1A-2 16r 3
252	2.768	0.115	1.322	0.006	0.459	0.003	2.278	0.009	0.005	0.000	0.032	0.947	0.098	0.003	8.043	1A-2 16c 1
254	2.779	0.109	1.286	0.007	0.517	0.005	2.253	0.008	0.009	0.002	0.051	0.931	0.081	0.002	8.041	1A-2 16c 3
256	2.644	0.103	1.451	0.001	0.342	0.003	2.445	0.039	0.010	0.000	0.031	0.946	0.053	0.000	8.068	1A-2 17c 2
257	2.634	0.110	1.446	0.002	0.356	0.004	2.446	0.036	0.012	0.000	0.022	0.947	0.043	0.001	8.059	1A-2 17c 3
258	2.772	0.157	1.249	0.007	0.422	0.003	2.318	0.014	0.007	0.003	0.028	0.957	0.032	0.001	7.968	1A-2 17r 1
259	2.661	0.080	1.430	0.000	0.356	0.004	2.464	0.048	0.015	0.001	0.015	0.957	0.033	0.000	8.062	1A-2 17r 2
263	2.666	0.136	1.399	0.000	0.374	0.004	2.391	0.038	0.008	0.001	0.041	0.923	0.039	0.006	8.025	1A-2 18r 3
264	2.669	0.124	1.432	0.000	0.342	0.003	2.389	0.036	0.002	0.001	0.026	0.962	0.032	0.003	8.019	1A-2 18c 1
265	2.679	0.136	1.392	0.002	0.378	0.004	2.377	0.034	0.006	0.001	0.030	0.934	0.026	0.001	7.998	1A-2 18c 2
266	2.707	0.140	1.335	0.001	0.427	0.003	2.336	0.019	0.022	0.000	0.043	0.953	0.035	0.005	8.024	1A-2 18c 3
267	2.664	0.131	1.433	0.000	0.359	0.003	2.381	0.036	0.004	0.000	0.029	0.930	0.027	0.001	7.997	1A-2 19c 1
268	2.758	0.153	1.253	0.008	0.427	0.002	2.342	0.014	0.002	0.001	0.034	0.964	0.045	0.002	8.004	1A-2 19c 2

Table Meliadine Phlogopite. (continued).

No.	Si	Ti	Al	Cr	Fe	Mn	Mg	Ba	Ca	Ni	Na	K	F	Cl	Total	Comment
271	2.772	0.154	1.187	0.002	0.547	0.002	2.341	0.011	0.018	0.001	0.034	0.858	0.044	0.003	7.973	1A-2 19r 2
272	2.649	0.113	1.460	0.001	0.390	0.004	2.363	0.043	0.010	0.001	0.038	0.913	0.029	0.001	8.013	1A-2 19r 3
285	2.625	0.101	1.489	0.000	0.344	0.004	2.427	0.047	0.012	0.002	0.023	0.937	0.048	0.002	8.060	1A-2 22r 1
286	2.634	0.099	1.467	0.000	0.346	0.004	2.434	0.043	0.015	0.000	0.022	0.962	0.041	0.003	8.069	1A-2 22r 2
287	2.655	0.089	1.416	0.000	0.398	0.005	2.438	0.047	0.027	0.000	0.028	0.920	0.063	0.003	8.089	1A-2 22r 3
291	2.646	0.102	1.467	0.000	0.335	0.002	2.425	0.045	0.007	0.000	0.028	0.955	0.045	0.002	8.058	1A-2 23c 1
292	2.633	0.104	1.486	0.000	0.343	0.004	2.417	0.043	0.009	0.001	0.025	0.934	0.044	0.004	8.047	1A-2 23c 2
295	2.698	0.100	1.454	0.001	0.735	0.004	1.969	0.002	0.006	0.003	0.063	0.944	0.048	0.004	8.030	1A-2 23r 2
296	2.736	0.083	1.317	0.000	0.351	0.002	2.489	0.039	0.015	0.000	0.018	0.959	0.062	0.002	8.075	1A-2 23r 3
297	2.643	0.090	1.474	0.000	0.331	0.004	2.459	0.042	0.011	0.000	0.026	0.928	0.043	0.001	8.052	1A-2 24r 1
298	2.750	0.225	1.375	0.000	1.203	0.009	1.272	0.007	0.006	0.003	0.036	0.940	0.097	0.012	7.934	1A-2 24r 2
300	2.652	0.108	1.472	0.000	0.329	0.002	2.422	0.038	0.003	0.001	0.029	0.925	0.019	0.000	8.000	1A-2 24c 1
301	2.738	0.233	1.382	0.000	1.174	0.007	1.291	0.005	0.001	0.002	0.045	0.965	0.106	0.012	7.961	1A-2 24c 2
312	2.743	0.170	1.258	0.007	0.425	0.001	2.345	0.013	0.009	0.004	0.033	0.926	0.024	0.002	7.960	1A-2 26c 1
314	2.725	0.165	1.286	0.003	0.430	0.001	2.352	0.014	0.007	0.006	0.032	0.921	0.016	0.001	7.958	1A-2 26c 3
318	2.630	0.116	1.484	0.000	0.332	0.003	2.423	0.053	0.012	0.001	0.019	0.897	0.008	0.000	7.979	1A-2 27r 1
323	2.624	0.104	1.480	0.000	0.346	0.005	2.451	0.037	0.015	0.000	0.026	0.919	0.018	0.000	8.023	1b 1r 3
324	2.564	0.127	1.524	0.001	0.350	0.005	2.410	0.060	0.022	0.002	0.023	0.940	0.000	0.001	8.029	1b 1c 1
328	2.535	0.121	1.524	0.000	0.363	0.006	2.462	0.049	0.009	0.000	0.030	0.997	0.018	0.001	8.114	1b 2c 2
332	2.610	0.122	1.483	0.001	0.353	0.004	2.424	0.051	0.006	0.001	0.025	0.918	0.009	0.001	8.007	1b 3r 1
333	2.668	0.107	1.414	0.000	0.366	0.004	2.440	0.042	0.008	0.000	0.025	0.914	0.009	0.000	7.996	1b 3r 2
334	2.646	0.116	1.450	0.000	0.359	0.005	2.396	0.049	0.013	0.000	0.020	0.942	0.012	0.002	8.008	1b 3r 3
335	2.660	0.107	1.433	0.000	0.341	0.005	2.454	0.046	0.008	0.003	0.025	0.900	0.018	0.001	7.999	1b 3c 1
336	2.636	0.117	1.481	0.001	0.342	0.004	2.407	0.048	0.007	0.000	0.026	0.902	0.000	0.003	7.973	1b 3c 2
337	2.665	0.110	1.399	0.000	0.367	0.005	2.454	0.038	0.006	0.001	0.027	0.936	0.004	0.003	8.014	1b 3c 3
338	2.619	0.122	1.490	0.000	0.323	0.003	2.447	0.050	0.005	0.001	0.018	0.895	0.001	0.000	7.972	1b 3c 4
339	2.739	0.122	1.537	0.002	1.351	0.008	1.087	0.008	0.000	0.007	0.055	0.964	0.027	0.009	7.915	1b 4c 1
340	2.742	0.125	1.476	0.001	1.390	0.008	1.157	0.008	0.006	0.007	0.053	0.895	0.044	0.009	7.921	1b 4c 2
341	2.774	0.063	1.404	0.000	0.322	0.003	2.414	0.018	0.003	0.003	0.030	0.886	0.058	0.000	7.977	1b 4c 3
342	2.690	0.111	1.425	0.000	0.355	0.004	2.378	0.043	0.005	0.002	0.025	0.919	0.006	0.001	7.965	1b 4r 1
344	2.660	0.112	1.441	0.000	0.368	0.003	2.396	0.041	0.011	0.003	0.030	0.914	0.001	0.000	7.979	1b 4r 3
345	2.651	0.099	1.451	0.000	0.350	0.003	2.423	0.048	0.014	0.001	0.027	0.948	0.005	0.000	8.017	1b 5r 1
346	2.612	0.112	1.481	0.000	0.341	0.003	2.426	0.057	0.011	0.002	0.026	0.955	0.010	0.001	8.036	1b 5r 2
347	2.619	0.121	1.483	0.000	0.329	0.004	2.413	0.062	0.009	0.002	0.021	0.932	0.029	0.001	8.025	1b 5r 3
348	2.638	0.105	1.458	0.000	0.346	0.003	2.439	0.045	0.005	0.002	0.023	0.951	0.009	0.000	8.025	1b 5c 1
349	2.633	0.108	1.468	0.000	0.348	0.004	2.429	0.046	0.006	0.001	0.022	0.942	0.002	0.000	8.010	1b 5c 2
350	2.634	0.114	1.461	0.000	0.349	0.003	2.419	0.053	0.003	0.001	0.027	0.940	0.018	0.000	8.023	1b 5c 3
351	2.556	0.130	1.421	0.000	0.322	0.003	2.341	0.045	0.320	0.004	0.035	0.890	0.025	0.001	8.093	1b 6c 1

Table Meliadine Phlogop[illegible]continued).

No.	Si	Ti	Al	Cr	Fe	Mn	Mg	Ba	Ca	Ni	Na	K	F	Cl	Total	Comment
352	2.650	0.128	1.423	0.000	0.332	0.002	2.366	0.045	0.102	0.003	0.034	0.889	0.034	0.000	8.006	Ib 6c 2
353	2.636	0.127	1.501	0.000	0.314	0.001	2.380	0.048	0.014	0.002	0.028	0.903	0.003	0.000	7.956	Ib 6c 3
355	2.679	0.097	1.406	0.000	0.344	0.003	2.461	0.043	0.017	0.001	0.031	0.907	0.006	0.001	7.996	Ib 6r 2
356	2.643	0.099	1.462	0.000	0.331	0.003	2.431	0.043	0.023	0.003	0.020	0.962	0.000	0.001	8.020	Ib 6r 3
357	2.690	0.088	1.404	0.000	0.335	0.004	2.448	0.038	0.029	0.000	0.020	0.946	0.003	0.000	8.006	Ib 7r 1
358	2.708	0.093	1.390	0.000	0.375	0.004	2.405	0.039	0.022	0.002	0.031	0.900	0.031	0.000	8.000	Ib 7r 2
359	2.662	0.109	1.460	0.000	0.341	0.002	2.403	0.040	0.011	0.001	0.036	0.903	0.009	0.000	7.977	Ib 7r 3
360	2.625	0.111	1.484	0.000	0.361	0.003	2.410	0.047	0.013	0.002	0.028	0.902	0.010	0.000	7.996	Ib 7c 1
361	2.609	0.122	1.486	0.000	0.348	0.006	2.414	0.052	0.014	0.001	0.031	0.920	0.002	0.000	8.004	Ib 7c 2
362	2.631	0.113	1.477	0.000	0.334	0.004	2.419	0.048	0.024	0.002	0.021	0.912	0.019	0.000	8.003	Ib 7c 3
363	2.607	0.121	1.500	0.000	0.351	0.005	2.404	0.054	0.004	0.003	0.029	0.917	0.011	0.000	8.006	Ib 8c 1
364	2.619	0.123	1.464	0.000	0.388	0.004	2.419	0.049	0.006	0.001	0.038	0.869	0.016	0.001	7.997	Ib 8c 2
365	2.622	0.119	1.506	0.000	0.347	0.004	2.383	0.052	0.004	0.001	0.028	0.907	0.016	0.000	7.989	Ib 8c 3
367	2.642	0.112	1.480	0.000	0.337	0.004	2.401	0.045	0.004	0.000	0.035	0.926	0.013	0.000	7.999	Ib 8r 2
368	2.665	0.099	1.452	0.000	0.330	0.005	2.434	0.043	0.003	0.000	0.030	0.928	0.010	0.000	7.999	Ib 8r 3
369	2.645	0.122	1.480	0.000	0.323	0.004	2.404	0.042	0.020	0.002	0.026	0.877	0.003	0.000	7.946	Ib 9r 1
370	2.637	0.122	1.468	0.000	0.313	0.004	2.434	0.046	0.022	0.000	0.028	0.901	0.009	0.000	7.982	Ib 9r 2
371	2.743	0.114	1.343	0.000	0.313	0.003	2.398	0.040	0.037	0.001	0.034	0.925	0.077	0.000	8.028	Ib 9r 3
372	2.668	0.097	1.436	0.000	0.336	0.004	2.463	0.037	0.006	0.002	0.026	0.912	0.004	0.000	7.991	Ib 9c 1
373	2.619	0.114	1.484	0.000	0.349	0.006	2.431	0.047	0.005	0.003	0.026	0.915	0.012	0.000	8.007	Ib 9c 2
374	2.626	0.116	1.475	0.000	0.338	0.004	2.434	0.053	0.006	0.001	0.026	0.908	0.004	0.001	7.991	Ib 9c 3
375	2.641	0.120	1.484	0.000	0.338	0.004	2.393	0.048	0.005	0.000	0.027	0.904	0.007	0.000	7.969	Ib 10c 1
376	2.629	0.116	1.481	0.000	0.334	0.004	2.419	0.050	0.006	0.000	0.032	0.919	0.004	0.000	7.994	Ib 10c 2
377	2.625	0.119	1.494	0.000	0.325	0.003	2.412	0.052	0.005	0.000	0.025	0.924	0.011	0.000	7.994	Ib 10c 3
378	2.614	0.117	1.500	0.000	0.350	0.004	2.414	0.052	0.008	0.000	0.016	0.905	0.014	0.002	7.996	Ib 10r 1
379	2.709	0.100	1.340	0.000	0.377	0.004	2.464	0.028	0.010	0.000	0.025	0.956	0.015	0.001	8.028	Ib 10r 2
380	2.626	0.113	1.458	0.000	0.372	0.005	2.428	0.042	0.011	0.002	0.024	0.928	0.032	0.002	8.042	Ib 10r 3
381	2.640	0.102	1.465	0.000	0.331	0.004	2.442	0.043	0.014	0.000	0.022	0.944	0.014	0.000	8.022	Ib 11r 1
382	2.623	0.118	1.457	0.000	0.355	0.004	2.423	0.056	0.023	0.000	0.022	0.923	0.037	0.003	8.043	Ib 11c 1
383	2.624	0.113	1.466	0.000	0.354	0.004	2.441	0.050	0.013	0.000	0.024	0.909	0.028	0.002	8.027	Ib 12c 1
384	2.683	0.096	1.408	0.000	0.345	0.006	2.444	0.038	0.015	0.000	0.020	0.948	0.022	0.000	8.023	Ib 12r 1
385	2.809	0.093	1.127	0.000	0.470	0.004	2.498	0.019	0.025	0.000	0.031	0.949	0.035	0.000	8.060	Ib 13
387	2.814	0.088	1.114	0.000	0.476	0.005	2.525	0.017	0.014	0.001	0.032	0.940	0.049	0.001	8.077	Ib 15
388	2.695	0.076	1.354	0.000	0.367	0.004	2.489	0.032	0.045	0.002	0.017	0.954	0.029	0.001	8.066	Ib 16
389	2.668	0.086	1.414	0.000	0.359	0.005	2.464	0.037	0.022	0.000	0.019	0.947	0.031	0.001	8.053	Ib 17
390	2.710	0.078	1.349	0.000	0.358	0.005	2.482	0.027	0.031	0.000	0.051	0.947	0.021	0.038	8.096	Ib 18
391	2.682	0.100	1.380	0.000	0.371	0.003	2.442	0.040	0.021	0.001	0.021	0.953	0.027	0.000	8.042	Ib 19
392	2.667	0.087	1.401	0.000	0.352	0.005	2.495	0.036	0.017	0.000	0.023	0.949	0.030	0.000	8.062	Ib 20

Table Meliadine Phlogopite. (continued).

No.	Si	Ti	Al	Cr	Fe	Mn	Mg	Ba	Ca	Ni	Na	K	F	Cl	Total	Comment
393	2.655	0.085	1.427	0.000	0.351	0.005	2.457	0.040	0.036	0.001	0.021	0.956	0.030	0.001	8.065	lb 21
394	2.604	0.107	1.491	0.000	0.351	0.005	2.426	0.051	0.031	0.000	0.022	0.935	0.024	0.003	8.048	lb 22
395	2.577	0.129	1.520	0.001	0.334	0.003	2.407	0.061	0.022	0.000	0.028	0.934	0.023	0.003	8.041	lb 23
396	2.673	0.094	1.369	0.000	0.364	0.003	2.494	0.042	0.023	0.000	0.022	0.952	0.052	0.002	8.089	lb 24
398	3.700	0.063	0.069	0.001	0.322	0.003	2.281	0.001	0.220	0.000	0.137	0.947	1.164	0.000	8.908	lb 25r 2
399	2.623	0.129	1.461	0.005	0.332	0.004	2.433	0.042	0.009	0.000	0.036	0.923	0.000	0.001	7.996	lb 25r 3
400	2.622	0.128	1.463	0.005	0.329	0.004	2.431	0.046	0.005	0.000	0.030	0.937	0.000	0.000	8.000	lb 25c 1
401	2.620	0.131	1.477	0.008	0.333	0.003	2.398	0.050	0.009	0.000	0.030	0.925	0.000	0.001	7.985	lb 25c 2
402	2.625	0.129	1.472	0.005	0.333	0.003	2.404	0.051	0.005	0.000	0.026	0.934	0.000	0.000	7.988	lb 25c 3
409	2.636	0.140	1.442	0.002	0.335	0.005	2.390	0.042	0.008	0.001	0.045	0.955	0.000	0.012	8.014	lb 32
411	2.651	0.094	1.421	0.004	0.361	0.004	2.446	0.041	0.014	0.001	0.042	0.971	0.000	0.016	8.065	lb 34
414	3.475	0.025	0.345	0.007	0.355	0.005	2.561	0.009	0.025	0.001	0.105	0.930	0.544	0.004	8.389	lb 37
415	2.889	0.068	1.149	0.007	0.343	0.005	2.526	0.029	0.036	0.001	0.057	0.767	0.132	0.005	8.014	lb 38
416	2.660	0.095	1.396	0.003	0.369	0.005	2.474	0.048	0.015	0.001	0.034	0.931	0.000	0.003	8.032	lb 39
519	2.771	0.203	1.298	0.001	1.246	0.015	1.353	0.004	0.005	0.000	0.039	0.930	0.073	0.010	7.945	upper 1c 1 z
520	2.784	0.196	1.289	0.000	1.253	0.016	1.334	0.002	0.009	0.000	0.041	0.952	0.072	0.011	7.955	upper 1c 2 z
521	2.740	0.186	1.308	0.000	1.307	0.017	1.399	0.002	0.005	0.002	0.037	0.874	0.077	0.009	7.962	upper 1c 3 z
522	2.706	0.090	1.343	0.000	0.382	0.004	2.491	0.026	0.010	0.000	0.027	0.937	0.022	0.000	8.036	upper 1r 1 z
523	2.564	0.102	1.377	0.000	0.711	0.004	2.474	0.027	0.006	0.000	0.031	0.735	0.034	0.001	8.064	upper 1r 2 z
524	2.676	0.131	1.336	0.000	0.466	0.005	2.412	0.025	0.009	0.000	0.037	0.895	0.018	0.000	8.009	upper 1r 3 z
525	2.649	0.116	1.450	0.000	0.337	0.003	2.436	0.041	0.007	0.000	0.023	0.923	0.013	0.001	7.996	upper 2r 1
526	2.731	0.168	1.298	0.000	0.396	0.000	2.370	0.012	0.008	0.000	0.032	0.909	0.023	0.000	7.946	upper 2r 2
527	2.647	0.134	1.444	0.000	0.315	0.004	2.435	0.036	0.006	0.000	0.027	0.931	0.016	0.000	7.994	upper 2r 3
528	2.627	0.124	1.482	0.000	0.316	0.002	2.438	0.043	0.004	0.000	0.025	0.922	0.010	0.001	7.993	upper 2c 1
529	2.744	0.177	1.259	0.002	0.398	0.003	2.350	0.011	0.002	0.000	0.036	0.968	0.022	0.000	7.973	upper 2c 2
530	2.741	0.175	1.256	0.004	0.400	0.003	2.380	0.011	0.003	0.000	0.030	0.936	0.015	0.000	7.953	upper 2c 3
531	2.818	0.081	1.210	0.000	1.076	0.010	1.789	0.006	0.003	0.000	0.145	0.863	0.085	0.002	8.086	upper 3c 1 z
532	2.854	0.075	1.187	0.000	1.046	0.012	1.786	0.003	0.002	0.000	0.132	0.891	0.077	0.001	8.067	upper 3c 2 z
533	2.812	0.078	1.270	0.000	1.092	0.010	1.694	0.004	0.009	0.002	0.130	0.879	0.070	0.001	8.050	upper 3c 3 z
534	2.648	0.101	1.469	0.000	0.318	0.003	2.459	0.037	0.007	0.000	0.021	0.927	0.009	0.000	7.999	upper 3r 1 z
535	2.640	0.111	1.477	0.000	0.306	0.001	2.454	0.039	0.005	0.000	0.033	0.924	0.009	0.000	7.999	upper 3r 2 z
536	2.643	0.118	1.469	0.000	0.307	0.002	2.433	0.041	0.009	0.000	0.030	0.931	0.010	0.000	7.995	upper 3r 3 z
537	2.658	0.127	1.412	0.000	0.341	0.003	2.450	0.037	0.010	0.000	0.026	0.915	0.013	0.000	7.992	upper 4r 1
538	2.649	0.107	1.440	0.000	0.332	0.003	2.463	0.034	0.013	0.000	0.035	0.932	0.029	0.000	8.036	upper 4r 2
539	2.673	0.097	1.407	0.000	0.331	0.004	2.488	0.035	0.011	0.001	0.021	0.938	0.022	0.000	8.028	upper 4r 3
540	2.745	0.181	1.241	0.008	0.403	0.002	2.357	0.013	0.008	0.003	0.038	0.942	0.024	0.004	7.968	upper 4c 1
541	2.742	0.172	1.251	0.008	0.396	0.003	2.369	0.013	0.006	0.002	0.038	0.952	0.026	0.002	7.979	upper 4c 2
542	2.658	0.105	1.424	0.000	0.337	0.004	2.467	0.029	0.011	0.002	0.032	0.945	0.017	0.002	8.032	upper 4c 3

Table Meliadine Phlogopite. (continued).

No.	Si	Ti	Al	Cr	Fe	Mn	Mg	Ba	Ca	Ni	Na	K	F	Cl	Total	Comment
543	2.678	0.143	1.387	0.000	0.338	0.003	2.410	0.029	0.007	0.002	0.028	0.953	0.015	0.002	7.993	upper 5c 1
544	2.650	0.111	1.456	0.000	0.324	0.004	2.426	0.040	0.008	0.001	0.022	0.963	0.010	0.002	8.015	upper 5c 2
545	2.748	0.171	1.241	0.005	0.411	0.002	2.351	0.014	0.008	0.004	0.031	0.978	0.014	0.002	7.979	upper 5c 3
546	2.719	0.090	1.332	0.000	0.363	0.004	2.483	0.027	0.010	0.000	0.024	0.973	0.023	0.002	8.048	upper 5r 1
547	2.751	0.070	1.290	0.000	0.362	0.003	2.523	0.020	0.009	0.000	0.020	0.990	0.019	0.002	8.059	upper 5r 2
548	2.658	0.108	1.438	0.000	0.329	0.005	2.444	0.040	0.012	0.000	0.027	0.940	0.015	0.001	8.015	upper 5r 3
549	2.731	0.172	1.259	0.007	0.409	0.002	2.358	0.013	0.009	0.003	0.029	0.972	0.014	0.002	7.980	upper 6r 1
550	2.762	0.167	1.226	0.005	0.400	0.002	2.374	0.014	0.007	0.002	0.031	0.963	0.025	0.001	7.978	upper 6r 2
551	2.627	0.119	1.470	0.000	0.324	0.004	2.436	0.044	0.011	0.001	0.021	0.948	0.018	0.001	8.022	upper 6r 3
552	2.747	0.172	1.243	0.007	0.404	0.002	2.366	0.012	0.005	0.003	0.030	0.960	0.018	0.002	7.970	upper 6c 1
553	2.758	0.166	1.240	0.009	0.396	0.001	2.358	0.012	0.006	0.001	0.028	0.985	0.015	0.001	7.975	upper 6c 2
554	2.653	0.102	1.448	0.000	0.325	0.005	2.455	0.038	0.008	0.000	0.019	0.957	0.018	0.002	8.030	upper 6c 3
555	2.922	0.093	1.199	0.002	1.152	0.031	1.449	0.007	0.010	0.001	0.045	0.989	0.565	0.008	8.474	upper 7c 1 brown
556	2.950	0.093	1.203	0.003	1.123	0.032	1.425	0.008	0.006	0.002	0.009	1.009	0.611	0.007	8.481	upper 7c 2 brown
557	2.904	0.097	1.209	0.004	1.153	0.033	1.463	0.006	0.006	0.000	0.024	1.013	0.609	0.005	8.524	upper 7c 3 brown
558	2.926	0.095	1.186	0.003	1.153	0.034	1.455	0.006	0.010	0.004	0.053	0.974	0.569	0.006	8.472	upper 7c 4 brown
559	2.927	0.096	1.199	0.000	1.153	0.031	1.439	0.007	0.013	0.001	0.027	0.999	0.579	0.004	8.473	upper 7r 1 brown
560	2.919	0.090	1.171	0.002	1.165	0.034	1.478	0.006	0.014	0.000	0.044	1.010	0.577	0.004	8.513	upper 7r 2 brown
561	2.911	0.095	1.188	0.001	1.172	0.031	1.442	0.006	0.011	0.001	0.081	1.000	0.565	0.005	8.509	upper 7r 3 brown
562	2.926	0.097	1.199	0.002	1.163	0.029	1.431	0.005	0.008	0.000	0.034	0.999	0.562	0.004	8.459	upper 7r 4 brown
563	2.804	0.093	1.125	0.001	0.436	0.002	2.548	0.017	0.010	0.000	0.033	0.977	0.002	0.000	8.047	upper 8r 1 z
564	2.771	0.097	1.211	0.000	0.395	0.001	2.533	0.019	0.009	0.000	0.032	0.949	0.008	0.000	8.026	upper 8r 2 z
565	2.674	0.103	1.406	0.000	0.344	0.002	2.451	0.036	0.008	0.000	0.029	0.965	0.000	0.000	8.017	upper 8r 3 z
566	2.783	0.192	1.328	0.002	1.248	0.014	1.269	0.002	0.005	0.001	0.037	0.996	0.045	0.001	7.924	upper 8c 1 z
567	2.771	0.197	1.324	0.004	1.258	0.015	1.275	0.002	0.006	0.001	0.032	0.995	0.054	0.005	7.940	upper 8c 2 z
568	2.777	0.194	1.328	0.006	1.237	0.013	1.275	0.001	0.002	0.002	0.034	1.018	0.056	0.004	7.947	upper 8c 3 z
569	2.788	0.193	1.316	0.003	1.259	0.014	1.257	0.003	0.004	0.002	0.039	1.008	0.047	0.003	7.934	upper 9c 1 z
570	2.794	0.194	1.321	0.002	1.242	0.014	1.258	0.002	0.004	0.000	0.043	0.998	0.048	0.001	7.920	upper 9c 2 z
571	2.782	0.189	1.322	0.003	1.252	0.016	1.273	0.001	0.006	0.000	0.046	0.999	0.044	0.004	7.937	upper 9c 3 z
572	2.615	0.124	1.455	0.001	0.362	0.002	2.443	0.048	0.010	0.000	0.027	0.919	0.002	0.001	8.009	upper 9r 1 z
573	2.627	0.127	1.441	0.000	0.384	0.002	2.407	0.046	0.013	0.000	0.034	0.928	0.005	0.001	8.013	upper 9r 2 z
574	2.683	0.099	1.379	0.000	0.355	0.003	2.472	0.032	0.007	0.000	0.032	0.965	0.002	0.001	8.031	upper 9r 3 z
575	2.649	0.112	1.440	0.000	0.329	0.001	2.451	0.039	0.012	0.000	0.036	0.939	0.000	0.000	8.007	upper 10r 1
576	2.686	0.091	1.396	0.000	0.346	0.003	2.464	0.039	0.007	0.000	0.031	0.958	0.000	0.000	8.020	upper 10r 2
577	2.622	0.128	1.446	0.000	0.367	0.002	2.434	0.042	0.009	0.000	0.042	0.914	0.000	0.000	8.005	upper 10r 3
578	2.648	0.110	1.440	0.001	0.332	0.001	2.454	0.039	0.005	0.000	0.035	0.949	0.000	0.000	8.014	upper 10c 1
579	2.628	0.115	1.477	0.000	0.337	0.004	2.436	0.040	0.007	0.000	0.021	0.929	0.014	0.001	8.009	upper 10c 2
580	2.693	0.139	1.237	0.073	0.800	0.007	2.066	0.023	0.007	0.008	0.078	0.844	0.021	0.001	7.995	upper 10c 3

Table Meliadine Phlogopite. (continued).

No.	Si	Ti	Al	Cr	Fe	Mn	Mg	Ba	Ca	Ni	Na	K	F	Cl	Total	Comment
581	2.737	0.147	1.277	0.000	0.463	0.004	2.324	0.015	0.006	0.000	0.042	0.965	0.020	0.000	8.000	upper 11c 1
582	2.653	0.118	1.435	0.000	0.332	0.003	2.432	0.043	0.005	0.000	0.029	0.950	0.015	0.000	8.016	upper 11c 2
583	2.677	0.137	1.384	0.000	0.348	0.003	2.415	0.031	0.004	0.000	0.031	0.961	0.016	0.000	8.007	upper 11c 3
584	2.658	0.100	1.416	0.000	0.358	0.003	2.468	0.037	0.010	0.000	0.023	0.947	0.018	0.000	8.038	upper 11r 1
585	2.728	0.069	1.323	0.000	0.362	0.005	2.530	0.029	0.008	0.000	0.024	0.955	0.022	0.001	8.053	upper 11r 2
586	2.638	0.110	1.444	0.000	0.346	0.004	2.442	0.040	0.008	0.000	0.025	0.972	0.018	0.000	8.046	upper 11r 3
587	2.671	0.150	1.378	0.000	0.354	0.004	2.390	0.027	0.012	0.000	0.035	0.971	0.014	0.000	8.006	upper 12r 1
588	2.656	0.141	1.409	0.000	0.340	0.004	2.431	0.031	0.008	0.000	0.025	0.934	0.008	0.001	7.987	upper 12r 2
589	2.620	0.109	1.468	0.000	0.331	0.004	2.462	0.041	0.013	0.000	0.024	0.958	0.015	0.002	8.045	upper 12r 3
590	2.656	0.145	1.401	0.000	0.336	0.004	2.434	0.031	0.007	0.000	0.026	0.949	0.024	0.000	8.010	upper 12c 1
591	2.751	0.139	1.281	0.000	0.483	0.003	2.289	0.012	0.007	0.000	0.046	0.963	0.028	0.000	8.002	upper 12c 2
592	2.635	0.121	1.458	0.000	0.321	0.002	2.443	0.042	0.006	0.000	0.022	0.956	0.021	0.000	8.026	upper 12c 3
593	2.622	0.127	1.472	0.000	0.324	0.002	2.425	0.048	0.002	0.000	0.025	0.963	0.013	0.000	8.023	upper 13c 1
594	2.627	0.115	1.472	0.000	0.327	0.004	2.438	0.044	0.005	0.000	0.025	0.959	0.012	0.001	8.027	upper 13c 2
595	2.625	0.124	1.481	0.000	0.322	0.003	2.435	0.048	0.004	0.000	0.021	0.918	0.013	0.000	7.993	upper 13c 3
596	2.633	0.118	1.476	0.000	0.313	0.004	2.431	0.045	0.008	0.000	0.027	0.941	0.024	0.000	8.019	upper 13r 1
597	2.762	0.079	1.270	0.000	0.404	0.004	2.503	0.025	0.015	0.000	0.027	0.897	0.032	0.002	8.020	upper 13r 2
598	2.643	0.097	1.447	0.000	0.328	0.003	2.473	0.041	0.010	0.000	0.026	0.959	0.021	0.000	8.050	upper 13r 3
599	2.338	0.087	1.238	0.003	1.732	0.002	2.395	0.008	0.037	0.000	0.012	0.219	0.044	0.000	8.114	upper 14 around ol
600	2.485	0.090	1.310	0.000	1.111	0.003	2.485	0.021	0.018	0.000	0.027	0.465	0.042	0.000	8.057	upper 14 around ol
601	2.670	0.109	1.454	0.003	0.380	0.003	2.345	0.043	0.010	0.000	0.031	0.927	0.004	0.000	7.976	upper 14 around ol
602	2.798	0.174	1.261	0.007	0.416	0.002	2.206	0.014	0.003	0.000	0.033	0.997	0.011	0.001	7.921	upper 15c 1
603	2.772	0.169	1.284	0.004	0.410	0.001	2.250	0.014	0.002	0.000	0.038	0.981	0.013	0.000	7.938	upper 15c 2
604	2.761	0.174	1.271	0.007	0.418	0.002	2.260	0.012	0.004	0.000	0.037	0.998	0.006	0.000	7.949	upper 15c 3
605	2.656	0.126	1.494	0.000	0.326	0.004	2.326	0.045	0.003	0.000	0.026	0.959	0.000	0.001	7.965	upper 15r 1
606	2.679	0.117	1.457	0.000	0.334	0.002	2.334	0.042	0.008	0.000	0.040	0.966	0.004	0.000	7.983	upper 15r 2
607	2.755	0.175	1.286	0.008	0.420	0.002	2.236	0.015	0.006	0.000	0.042	1.002	0.006	0.000	7.951	upper 15r 3
608	2.627	0.142	1.525	0.000	0.340	0.004	2.286	0.053	0.008	0.000	0.026	0.941	0.005	0.000	7.957	upper 16r 1
609	2.663	0.124	1.490	0.000	0.323	0.002	2.314	0.042	0.008	0.000	0.025	0.980	0.000	0.000	7.970	upper 16r 2
610	2.760	0.180	1.272	0.007	0.437	0.003	2.225	0.011	0.009	0.000	0.032	0.999	0.005	0.000	7.941	upper 16r 3
611	2.775	0.165	1.282	0.006	0.422	0.002	2.240	0.012	0.002	0.000	0.033	0.987	0.000	0.000	7.926	upper 16c 1
612	2.782	0.169	1.261	0.009	0.415	0.003	2.249	0.012	0.003	0.000	0.030	0.995	0.004	0.000	7.931	upper 16c 3
616	2.706	0.088	1.430	0.000	0.344	0.004	2.374	0.034	0.010	0.000	0.030	0.972	0.004	0.000	7.996	upper 17r 1
617	2.778	0.169	1.276	0.009	0.411	0.002	2.250	0.011	0.010	0.000	0.033	0.960	0.011	0.000	7.919	upper 17r 2
618	2.685	0.102	1.454	0.000	0.349	0.003	2.337	0.042	0.016	0.000	0.028	0.969	0.000	0.002	7.987	upper 17r 3
619	2.619	0.137	1.461	0.000	0.335	0.004	2.420	0.046	0.009	0.001	0.016	0.947	0.012	0.002	8.008	upper 18r 1
620	2.623	0.116	1.454	0.002	0.340	0.004	2.447	0.051	0.012	0.001	0.025	0.940	0.018	0.000	8.032	upper 18r 2
621	2.602	0.133	1.477	0.001	0.336	0.004	2.427	0.049	0.012	0.000	0.028	0.943	0.004	0.002	8.017	upper 18r 3

Table Meliadine Phlogopite. (continued).

No.	Si	Ti	Al	Cr	Fe	Mn	Mg	Ba	Ca	Ni	Na	K	F	Cl	Total	Comment
622	2.651	0.148	1.401	0.002	0.341	0.003	2.422	0.031	0.009	0.000	0.024	0.962	0.013	0.001	8.007	upper 18c 1
623	2.739	0.165	1.255	0.010	0.406	0.003	2.360	0.014	0.009	0.003	0.031	0.968	0.015	0.001	7.979	upper 18c 2
624	2.617	0.122	1.463	0.000	0.315	0.004	2.464	0.043	0.010	0.000	0.027	0.959	0.011	0.000	8.034	upper 18c 3
628	2.759	0.098	1.233	0.002	0.389	0.003	2.515	0.017	0.013	0.001	0.031	0.961	0.017	0.000	8.038	upper 19r 1 z
629	2.706	0.089	1.353	0.002	0.349	0.003	2.496	0.032	0.007	0.000	0.023	0.960	0.015	0.000	8.034	upper 19r 2 z
630	2.650	0.105	1.445	0.000	0.337	0.003	2.468	0.037	0.004	0.000	0.025	0.921	0.015	0.000	8.010	upper 19r 3 z
631	2.570	0.135	1.514	0.000	0.334	0.005	2.441	0.056	0.010	0.000	0.026	0.922	0.018	0.000	8.031	upper 20r 1
632	2.645	0.141	1.423	0.006	0.332	0.002	2.433	0.036	0.006	0.000	0.025	0.928	0.011	0.000	7.987	upper 20r 2
633	2.643	0.120	1.437	0.000	0.330	0.003	2.457	0.042	0.008	0.000	0.025	0.934	0.003	0.000	8.001	upper 20r 3
634	2.758	0.176	1.200	0.008	0.431	0.002	2.379	0.014	0.004	0.001	0.032	0.945	0.020	0.000	7.971	upper 20c 1
635	2.754	0.169	1.228	0.009	0.420	0.003	2.379	0.014	0.005	0.002	0.031	0.922	0.011	0.001	7.947	upper 20c 2
636	2.750	0.165	1.251	0.007	0.387	0.003	2.381	0.012	0.006	0.000	0.026	0.963	0.020	0.000	7.970	upper 20c 3
637	2.641	0.137	1.430	0.000	0.333	0.004	2.442	0.031	0.008	0.000	0.026	0.939	0.019	0.000	8.009	upper 21c 1
638	2.760	0.164	1.226	0.013	0.404	0.003	2.366	0.015	0.007	0.003	0.026	0.966	0.026	0.000	7.979	upper 21c 2
639	2.644	0.112	1.451	0.000	0.331	0.004	2.470	0.039	0.008	0.003	0.023	0.891	0.018	0.000	7.994	upper 21c 3
640	2.708	0.078	1.370	0.000	0.339	0.004	2.498	0.035	0.024	0.002	0.034	0.907	0.025	0.002	8.026	upper 21r 1
641	2.655	0.100	1.430	0.000	0.331	0.004	2.483	0.039	0.011	0.003	0.030	0.918	0.027	0.000	8.032	upper 21r 2
642	2.675	0.092	1.403	0.000	0.342	0.005	2.490	0.036	0.014	0.004	0.027	0.916	0.034	0.002	8.039	upper 21r 3
643	2.675	0.151	1.373	0.000	0.350	0.002	2.422	0.028	0.011	0.003	0.031	0.915	0.024	0.000	7.984	upper 22r 1
644	2.727	0.170	1.274	0.007	0.418	0.003	2.360	0.013	0.009	0.003	0.040	0.914	0.023	0.000	7.962	upper 22r 2
645	2.608	0.138	1.494	0.000	0.337	0.004	2.398	0.055	0.010	0.002	0.033	0.889	0.016	0.003	7.987	upper 22r 3
646	2.752	0.169	1.251	0.006	0.403	0.002	2.369	0.012	0.006	0.004	0.041	0.910	0.029	0.002	7.957	upper 22c 1
647	2.644	0.123	1.452	0.000	0.329	0.003	2.443	0.041	0.011	0.002	0.037	0.879	0.016	0.000	7.980	upper 22c 2
648	2.733	0.171	1.247	0.009	0.419	0.002	2.385	0.014	0.007	0.004	0.038	0.918	0.028	0.002	7.976	upper 22c 3
649	2.759	0.224	1.192	0.000	0.439	0.004	2.294	0.014	0.008	0.004	0.037	0.928	0.026	0.001	7.929	upper 23c 1
650	2.722	0.172	1.269	0.012	0.419	0.004	2.354	0.014	0.008	0.005	0.036	0.935	0.026	0.004	7.981	upper 23c 2
651	2.736	0.170	1.241	0.011	0.428	0.004	2.367	0.012	0.007	0.004	0.033	0.941	0.030	0.002	7.986	upper 23c 3
652	2.614	0.130	1.479	0.001	0.326	0.004	2.433	0.047	0.013	0.002	0.026	0.910	0.019	0.001	8.005	upper 23r 1
653	2.655	0.112	1.458	0.000	0.316	0.004	2.433	0.039	0.016	0.001	0.022	0.919	0.019	0.001	7.993	upper 23r 2
654	2.660	0.151	1.401	0.001	0.342	0.003	2.404	0.034	0.014	0.004	0.028	0.923	0.019	0.002	7.985	upper 23r 3
655	2.753	0.161	1.228	0.007	0.428	0.004	2.373	0.010	0.006	0.003	0.033	0.961	0.024	0.002	7.991	upper 24r 1
656	2.755	0.163	1.249	0.002	0.436	0.005	2.346	0.013	0.008	0.003	0.041	0.911	0.029	0.003	7.964	upper 24r 2
657	2.764	0.092	1.249	0.000	0.382	0.005	2.523	0.020	0.011	0.002	0.030	0.913	0.036	0.002	8.029	upper 24r 3
658	2.749	0.170	1.231	0.010	0.427	0.002	2.375	0.012	0.006	0.004	0.040	0.912	0.023	0.001	7.961	upper 24c 1
659	2.730	0.170	1.258	0.012	0.493	0.004	2.299	0.011	0.003	0.004	0.046	0.918	0.032	0.001	7.980	upper 24c 2
660	2.756	0.164	1.230	0.008	0.436	0.003	2.353	0.010	0.003	0.002	0.045	0.947	0.041	0.002	7.999	upper 24c 3
661	2.540	0.114	1.183	0.027	1.251	0.007	2.288	0.013	0.016	0.007	0.049	0.537	0.050	0.001	8.084	upper 25c 1 large
662	2.801	0.101	1.195	0.040	0.597	0.005	2.212	0.018	0.000	0.010	0.083	0.922	0.047	0.000	8.030	upper 25c 2 large

Table Meliadine Phlogopite. (continued).

No.	Si	Ti	Al	Cr	Fe	Mn	Mg	Ba	Ca	Ni	Na	K	F	Cl	Total	Comment
663	2.751	0.130	1.241	0.029	0.703	0.006	2.091	0.031	0.000	0.009	0.080	0.909	0.041	0.001	8.021	upper 25c 3 large
664	2.757	0.154	1.230	0.016	0.727	0.007	2.041	0.034	0.003	0.007	0.082	0.902	0.050	0.001	8.010	upper 25c 4 large
665	2.778	0.102	1.261	0.019	0.681	0.006	2.108	0.016	0.000	0.005	0.063	0.945	0.053	0.004	8.041	upper 25c 5 large
666	2.720	0.155	1.323	0.004	0.373	0.003	2.368	0.018	0.000	0.001	0.029	0.963	0.041	0.002	8.000	upper 25r 1 large
667	2.727	0.178	1.253	0.008	0.420	0.004	2.352	0.013	0.001	0.005	0.029	0.974	0.030	0.002	7.998	upper 25r 2 large
668	2.719	0.175	1.249	0.011	0.430	0.003	2.366	0.017	0.001	0.003	0.034	0.973	0.034	0.002	8.016	upper 25r 3 large
669	2.754	0.168	1.244	0.007	0.412	0.004	2.349	0.012	0.001	0.005	0.037	0.957	0.034	0.004	7.987	upper 25r 4 large
670	2.649	0.136	1.418	0.003	0.331	0.004	2.436	0.037	0.003	0.000	0.030	0.946	0.029	0.001	8.023	upper 25r 5 large
671	2.494	0.123	1.207	0.012	2.062	0.025	1.591	0.002	0.017	0.003	0.029	0.452	0.089	0.005	8.109	upper 26c 1 z
672	2.739	0.141	1.323	0.010	1.410	0.025	1.306	0.003	0.011	0.004	0.043	0.923	0.086	0.005	8.028	upper 26c 2 z
673	2.745	0.133	1.302	0.009	1.420	0.026	1.333	0.003	0.012	0.005	0.041	0.919	0.090	0.005	8.042	upper 26c 3 z
674	2.669	0.084	1.382	0.001	0.393	0.005	2.494	0.033	0.018	0.000	0.030	0.926	0.031	0.001	8.066	upper 26r 1 z
675	2.674	0.077	1.334	0.000	0.460	0.007	2.519	0.026	0.011	0.000	0.030	0.914	0.043	0.000	8.097	upper 26r 2 z
676	2.635	0.078	1.335	0.000	0.547	0.007	2.551	0.025	0.014	0.002	0.025	0.829	0.042	0.002	8.090	upper 26r 3 z
679	2.667	0.100	1.449	0.001	0.320	0.004	2.461	0.040	0.024	0.000	0.017	0.865	0.019	0.001	7.969	upper 28 1
680	2.647	0.113	1.466	0.000	0.330	0.004	2.435	0.048	0.022	0.000	0.017	0.869	0.019	0.001	7.970	upper 28 2
681	2.657	0.108	1.401	0.000	0.418	0.004	2.441	0.039	0.025	0.000	0.021	0.862	0.023	0.001	8.000	upper 29 1
682	2.609	0.103	1.385	0.000	0.571	0.004	2.471	0.033	0.026	0.000	0.022	0.767	0.027	0.001	8.018	upper 29 2
683	2.659	0.090	1.350	0.000	0.498	0.005	2.489	0.036	0.033	0.000	0.021	0.812	0.025	0.000	8.018	upper 30 1
684	2.698	0.092	1.359	0.000	0.375	0.005	2.475	0.042	0.025	0.000	0.020	0.899	0.023	0.001	8.013	upper 30 2
685	2.701	0.084	1.379	0.001	0.365	0.003	2.472	0.043	0.025	0.000	0.026	0.878	0.036	0.001	8.013	upper 31 1
686	2.685	0.092	1.420	0.000	0.350	0.003	2.455	0.040	0.024	0.000	0.025	0.865	0.022	0.001	7.981	upper 31 2
687	2.606	0.132	1.440	0.000	0.452	0.004	2.419	0.038	0.027	0.000	0.033	0.816	0.024	0.000	7.990	upper 32 1
688	2.582	0.098	1.353	0.000	0.669	0.003	2.523	0.027	0.028	0.000	0.031	0.692	0.029	0.000	8.035	upper 32 2
689	2.671	0.090	1.200	0.000	0.720	0.005	2.540	0.016	0.019	0.000	0.027	0.729	0.039	0.000	8.056	upper 33 1
690	2.649	0.085	1.344	0.000	0.520	0.004	2.519	0.028	0.027	0.000	0.034	0.809	0.022	0.001	8.039	upper 33 2
693	2.933	0.040	0.893	0.000	0.525	0.007	2.664	0.017	0.032	0.000	0.013	0.928	0.068	0.001	8.121	upper 35 1
694	2.785	0.048	1.241	0.000	0.327	0.006	2.618	0.034	0.025	0.000	0.017	0.910	0.041	0.000	8.052	upper 35 2
695	2.762	0.052	1.293	0.000	0.347	0.005	2.567	0.029	0.023	0.000	0.014	0.912	0.035	0.000	8.038	upper 35 3
696	2.705	0.117	1.290	0.000	0.438	0.006	2.456	0.029	0.026	0.000	0.021	0.912	0.028	0.000	8.027	upper 33 1
697	2.688	0.111	1.338	0.000	0.401	0.004	2.472	0.035	0.028	0.000	0.023	0.887	0.020	0.002	8.009	upper 33 2
698	2.734	0.081	1.327	0.000	0.348	0.004	2.513	0.025	0.020	0.001	0.019	0.921	0.028	0.000	8.019	upper 34 1
699	2.674	0.105	1.388	0.001	0.348	0.005	2.472	0.037	0.019	0.001	0.015	0.943	0.024	0.003	8.034	upper 34 2
700	2.678	0.098	1.391	0.001	0.325	0.006	2.478	0.038	0.026	0.000	0.015	0.962	0.036	0.002	8.055	upper 34 3
701	0.000	0.731	0.000	0.027	3.685	0.059	0.000	0.291	0.346	0.015	0.000	10.205	0.338	0.034	15.730	upper 35 1
702	0.000	0.819	0.000	0.000	3.768	0.051	0.000	0.267	0.330	0.001	0.000	9.892	0.350	0.020	15.497	upper 35 2
703	2.708	0.085	1.311	0.001	0.373	0.005	2.516	0.028	0.028	0.000	0.026	0.969	0.031	0.001	8.081	upper 36 1
704	2.660	0.105	1.398	0.002	0.346	0.005	2.466	0.035	0.031	0.002	0.032	0.938	0.021	0.002	8.043	upper 36 2
705	2.669	0.109	1.366	0.000	0.358	0.005	2.475	0.039	0.030	0.002	0.028	0.948	0.023	0.002	8.052	upper 36 3
706	2.690	0.077	1.227	0.003	0.568	0.005	2.557	0.021	0.034	0.000	0.032	0.839	0.035	0.002	8.090	upper 37 1
707	2.674	0.068	1.264	0.000	0.565	0.006	2.562	0.026	0.033	0.001	0.028	0.826	0.046	0.001	8.099	upper 37 2
708	2.739	0.070	1.299	0.002	0.358	0.006	2.518	0.029	0.022	0.002	0.019	0.975	0.034	0.002	8.074	upper 38 1

Table Meliadine Phlogopite. (continued).

No.	Si	Ti	Al	Cr	Fe	Mn	Mg	Ba	Ca	Ni	Na	K	F	Cl	Total	Comment
709	2.853	0.069	1.066	0.002	0.442	0.005	2.567	0.013	0.024	0.001	0.024	0.979	0.039	0.003	8.088	upper 38 2
710	2.689	0.087	1.301	0.003	0.405	0.006	2.531	0.035	0.034	0.002	0.020	0.941	0.037	0.002	8.092	upper 39 1
711	2.723	0.065	1.232	0.002	0.443	0.005	2.609	0.034	0.033	0.000	0.016	0.882	0.061	0.003	8.108	upper 39 2
712	2.756	0.248	1.320	0.002	1.170	0.011	1.285	0.007	0.003	0.004	0.040	1.018	0.092	0.011	7.967	upper 40 core 1 z
713	2.766	0.259	1.311	0.004	1.147	0.011	1.287	0.006	0.003	0.004	0.033	1.010	0.090	0.012	7.941	upper 40 core 2 z
714	2.640	0.167	1.366	0.001	0.384	0.004	2.402	0.036	0.010	0.001	0.028	0.967	0.026	0.003	8.036	upper 40 rim 1 z
715	2.643	0.117	1.432	0.000	0.333	0.003	2.455	0.042	0.008	0.002	0.028	0.949	0.029	0.003	8.043	upper 40 rim 2 z
716	2.701	0.094	1.334	0.001	0.368	0.005	2.490	0.031	0.007	0.001	0.031	0.982	0.036	0.002	8.082	upper 40 rim 3 z

Table Aya Phlogopite. Aya phlogopite compositions (wt. %).

No.	SiO2	TiO2	Al2O3	Cr2O3	FeO	MnO	MgO	BaO	CaO	NiO	Na2O	K2O	F	Cl	Total	Comment
4	38.77	1.92	14.54	1.48	11.18	0.07	18.30	0.73	0.00	0.09	0.15	8.91	0.61	0.00	96.49	5iBc 1-1
5	39.32	2.01	14.29	1.31	11.01	0.08	18.18	0.73	0.00	0.08	0.19	9.18	0.67	0.01	96.77	5iBc 1-2
6	38.76	2.01	14.72	1.45	10.75	0.07	18.13	0.84	0.00	0.09	0.20	9.30	0.62	0.00	96.65	5iBc 1-3
7	39.05	1.69	14.30	0.37	11.12	0.07	18.82	1.02	0.08	0.07	0.11	9.15	0.71	0.00	96.25	5iBr 1-1
8	39.25	1.55	14.41	0.08	10.76	0.07	19.38	1.11	0.09	0.09	0.15	8.93	0.80	0.03	96.34	5iBr 1-2
9	39.27	1.80	14.76	0.83	10.76	0.06	18.65	1.09	0.02	0.09	0.23	8.89	0.68	0.00	96.83	5iBr 1-3
10	39.29	2.07	14.76	1.04	11.21	0.03	18.34	0.52	0.02	0.09	0.16	9.00	0.66	0.00	96.91	5iBc 2-1
11	38.92	1.90	14.63	0.93	11.10	0.04	18.19	0.64	0.02	0.10	0.19	9.33	0.66	0.00	96.36	5iBc 2-2
12	39.07	2.02	14.27	1.86	10.85	0.03	18.09	0.57	0.01	0.10	0.19	9.18	0.64	0.00	96.59	5iBc 2-3
13	37.63	1.68	13.75	0.56	11.89	0.13	20.38	0.30	0.03	0.07	0.27	6.75	0.65	0.00	93.81	5iBr 2-1
14	38.73	1.71	14.13	0.66	11.18	0.08	19.31	0.50	0.02	0.10	0.19	8.45	0.63	0.01	95.43	5iBr 2-2
15	39.38	1.60	14.48	0.19	10.72	0.07	18.64	0.83	0.03	0.08	0.08	9.47	0.80	0.00	96.03	5iBr 2-3
16	38.83	2.03	14.05	1.47	10.79	0.05	18.01	0.73	0.00	0.13	0.25	8.93	0.59	0.07	95.65	5iBc 3-1
17	39.15	2.01	14.59	0.84	10.94	0.03	18.45	0.74	0.00	0.14	0.23	9.36	0.70	0.01	96.88	5iBc 3-2
18	39.96	1.69	14.12	0.33	10.63	0.04	19.04	0.96	0.01	0.09	0.08	9.64	0.82	0.00	97.06	5iBc 3-3
19	40.08	1.46	13.84	0.08	10.42	0.05	18.62	0.72	0.06	0.10	0.09	9.27	0.68	0.01	95.19	5iBr 3-1
20	39.75	2.07	14.23	1.09	11.05	0.05	18.45	0.99	0.02	0.11	0.19	9.24	0.67	0.02	97.62	5iBr 3-2
21	39.15	1.52	14.22	0.15	10.97	0.06	18.91	1.09	0.04	0.07	0.17	9.13	0.83	0.01	95.97	5iBr 3-3
22	39.45	1.53	14.89	0.02	10.67	0.04	18.74	0.76	0.00	0.13	0.19	9.24	0.73	0.00	96.08	5iB circle 2 c 4-1
23	39.17	1.52	14.75	0.07	10.50	0.04	18.64	0.80	0.02	0.10	0.14	9.05	0.75	0.00	95.25	5iB circle 2 c 4-2
24	39.59	1.53	14.57	0.06	10.47	0.06	18.93	0.79	0.01	0.09	0.19	9.26	0.79	0.00	96.00	5iB circle 2 c 4-3
25	38.84	1.54	14.44	0.05	10.39	0.05	18.74	0.93	0.03	0.10	0.19	9.13	0.77	0.02	94.87	5iB circle 2 r 4-1
26	40.23	1.62	14.36	0.07	10.52	0.05	19.42	0.78	0.00	0.09	0.11	9.51	0.89	0.00	97.29	5iB circle 2 r 4-2
27	39.56	1.62	14.89	0.07	10.91	0.09	17.76	0.91	0.07	0.13	0.06	9.73	0.80	0.01	96.25	5iB circle 2 r 4-3
28	40.13	1.70	14.16	0.33	10.80	0.05	19.19	1.35	0.01	0.12	0.21	8.71	0.77	0.00	97.19	5iB circle 2 c 5-1
29	40.52	1.52	13.88	0.28	10.56	0.03	19.41	0.77	0.02	0.10	0.20	8.58	0.77	0.00	96.29	5iB circle 2 c 5-2
30	39.69	1.59	15.01	0.41	10.65	0.05	18.77	0.95	0.06	0.12	0.21	8.79	0.63	0.00	96.66	5iB circle 2 c 5-3
31	38.84	1.67	15.04	0.83	10.63	0.07	18.03	1.04	0.06	0.09	0.20	8.53	0.62	0.01	95.39	5iB circle 2 r 5-1
32	38.47	1.57	14.59	0.38	10.64	0.07	18.24	0.83	0.07	0.11	0.16	8.59	0.67	0.00	94.10	5iB circle 2 r 5-2
33	38.93	1.54	13.72	0.17	10.67	0.10	19.39	0.73	0.21	0.10	0.19	7.38	0.64	0.02	93.52	5iB circle 2 r 5-3
34	39.35	2.31	13.87	0.36	9.45	0.05	19.35	0.71	0.00	0.14	0.21	9.06	0.74	0.02	95.30	5iA circle 1 c 1-1
35	39.31	1.51	14.06	0.43	9.74	0.05	19.72	0.87	0.00	0.11	0.22	9.16	0.74	0.02	95.63	5iA circle 1 c 1-2
36	38.75	2.28	13.95	1.64	9.77	0.09	18.65	0.74	0.01	0.10	0.24	9.18	0.66	0.03	95.80	5iA circle 1 c 1-3
37	39.08	1.44	13.71	0.04	9.56	0.06	19.26	1.12	0.01	0.13	0.19	9.01	0.78	0.02	94.07	5iA circle 1 r 1-1
38	39.31	1.43	14.19	0.03	9.71	0.06	19.54	0.74	0.00	0.10	0.22	9.34	0.66	0.02	95.06	5iA circle 1 r 1-2
39	38.89	2.05	13.73	0.67	9.93	0.07	19.19	0.81	0.02	0.09	0.17	9.07	0.73	0.02	95.13	5iA circle 1 r 1-3
40	39.68	1.53	13.96	0.08	9.58	0.09	19.93	0.97	0.00	0.15	0.18	9.24	0.77	0.04	95.85	5iA circle 1 c 2-1
41	39.64	1.56	13.88	0.91	9.58	0.05	19.43	0.75	0.00	0.10	0.18	9.13	0.73	0.03	95.65	5iA circle 1 c 2-2

Table Aya Phlogopite. (continued).

No.	SiO2	TiO2	Al2O3	Cr2O3	FeO	MnO	MgO	BaO	CaO	NiO	Na2O	K2O	F	Cl	Total	Comment
42	39.12	1.46	14.00	0.48	9.86	0.07	19.53	0.70	0.01	0.09	0.17	9.14	0.71	0.03	95.06	5iA circle 1 c 2-3
43	39.79	1.33	13.23	0.14	9.42	0.07	19.87	0.77	0.05	0.14	0.08	9.52	0.87	0.02	94.93	5iA circle 1 r 2-1
44	39.01	2.23	13.86	1.50	9.91	0.08	18.74	0.73	0.01	0.11	0.15	9.02	0.64	0.01	95.73	5iA circle 1 r 2-2
45	38.69	1.61	14.16	1.28	9.78	0.05	19.19	0.70	0.00	0.15	0.12	9.19	0.64	0.04	95.32	5iA circle 1 r 2-3
46	38.96	1.56	13.82	0.89	9.56	0.07	18.96	0.70	0.00	0.09	0.22	8.93	0.65	0.02	94.14	5iA circle 2 c 1-1
47	38.83	1.76	13.67	0.55	9.96	0.05	19.38	0.65	0.02	0.13	0.12	9.22	0.76	0.01	94.80	5iA circle 2 c 1-2
48	39.36	1.87	13.47	0.79	9.59	0.05	19.41	0.66	0.00	0.17	0.15	9.26	0.71	0.02	95.19	5iA circle 2 c 1-3
49	38.80	1.21	13.50	0.16	9.53	0.09	19.71	0.63	0.01	0.10	0.11	8.97	0.74	0.04	93.28	5iA circle 2 r 1-1
50	38.58	1.28	13.78	0.16	9.81	0.09	19.93	0.90	0.05	0.12	0.09	8.82	0.81	0.03	94.08	5iA circle 2 r 1-2
51	38.97	1.56	13.69	0.90	9.82	0.05	18.88	0.77	0.02	0.13	0.17	9.06	0.67	0.03	94.45	5iA circle 2 r 1-3
52	38.85	1.47	14.13	0.18	10.35	0.07	18.72	0.70	0.09	0.13	0.20	9.30	0.66	0.03	94.60	5iA circle 2 c 2-1
53	38.73	1.52	13.70	0.83	9.91	0.05	18.61	0.66	0.07	0.09	0.21	8.98	0.56	0.04	93.71	5iA circle 2 c 2-2
54	39.32	1.53	14.07	0.70	9.85	0.07	18.94	0.69	0.09	0.11	0.12	8.73	0.70	0.01	94.63	5iA circle 2 c 2-3
55	38.10	1.35	13.55	0.17	9.93	0.08	19.06	0.97	0.06	0.09	0.07	9.12	0.79	0.03	93.05	5iA circle 2 r 2-1
56	39.47	1.42	13.86	0.00	9.93	0.10	19.85	0.65	0.17	0.11	0.09	8.86	0.89	0.04	95.05	5iA circle 2 r 2-2
57	37.80	1.31	14.21	0.41	10.31	0.08	20.05	0.56	0.22	0.11	0.15	8.06	0.69	0.02	93.67	5iA circle 2 r 2-3
58	39.61	1.66	14.25	0.83	9.41	0.08	19.50	0.74	0.10	0.12	0.20	9.21	0.68	0.02	96.10	5iA circle 3 r 1-1
59	39.78	1.37	14.11	0.31	9.83	0.07	19.58	0.92	0.10	0.16	0.10	9.51	0.79	0.02	96.30	5iA circle 3 r 1-2
60	39.87	1.44	14.58	0.07	9.22	0.09	19.01	0.78	0.07	0.09	0.07	9.03	0.84	0.01	94.83	5iA circle 3 r 1-3
61	39.10	1.84	14.31	1.49	9.49	0.04	18.90	0.91	0.02	0.10	0.19	9.19	0.62	0.02	95.96	5iA circle 3 c 1-1
62	39.11	1.72	14.26	1.28	9.90	0.08	18.90	0.78	0.03	0.10	0.22	9.05	0.62	0.02	95.78	5iA circle 3 c 1-2
63	38.85	1.64	14.03	0.84	9.78	0.08	19.23	0.66	0.05	0.11	0.19	8.77	0.65	0.04	94.65	5iA circle 3 c 1-3
64	38.61	1.69	14.24	1.44	9.75	0.09	18.82	0.78	0.03	0.11	0.15	9.19	0.66	0.02	95.29	5iA circle 3 c 2-1
65	38.67	1.88	13.96	0.95	9.98	0.10	18.73	0.56	0.05	0.11	0.09	9.35	0.70	0.02	94.84	5iA circle 3 c 2-2
66	39.34	1.55	14.47	1.01	9.69	0.06	19.01	0.65	0.03	0.13	0.16	8.98	0.69	0.01	95.47	5iA circle 3 c 2-3
67	38.96	1.54	14.23	0.72	9.78	0.09	19.28	0.74	0.04	0.09	0.17	8.90	0.71	0.02	94.96	5iA circle 3 r 2-1
68	39.92	1.51	13.88	0.57	9.37	0.09	19.65	0.65	0.02	0.10	0.20	9.25	0.76	0.01	95.65	5iA circle 3 r 2-2
69	38.62	1.50	14.39	0.80	11.25	0.07	18.51	0.62	0.10	0.12	0.19	8.35	0.70	0.01	94.92	5iA circle 3 r 2-3
70	38.83	1.52	14.57	0.75	9.57	0.08	19.28	0.74	0.02	0.09	0.20	9.34	0.70	0.01	95.40	5iA circle 4 r 1-1
71	40.04	1.46	13.81	0.01	9.38	0.06	20.18	0.67	0.11	0.10	0.20	9.23	0.77	0.01	95.69	5iA circle 4 r 1-2
72	38.97	1.22	14.40	0.17	9.85	0.09	19.84	0.65	0.03	0.12	0.12	8.98	0.74	0.02	94.87	5iA circle 4 r 1-3
73	38.93	2.01	14.28	1.24	9.90	0.07	18.75	0.68	0.02	0.12	0.21	9.05	0.63	0.02	95.63	5iA circle 4 c 1-1
74	39.60	1.50	14.21	0.37	10.06	0.03	19.11	0.88	0.02	0.13	0.19	8.99	0.68	0.01	95.47	5iA circle 4 c 1-2
75	39.15	1.55	13.87	1.00	9.45	0.06	18.86	0.66	0.00	0.09	0.19	9.12	0.61	0.01	94.37	5iA circle 4 c 1-3
76	38.78	1.44	13.57	0.71	10.11	0.05	18.96	0.65	0.03	0.11	0.18	8.88	0.67	0.03	93.88	5iA circle 4 c 2-1
77	38.71	1.71	13.83	1.37	9.59	0.05	18.87	0.68	0.03	0.07	0.25	9.22	0.60	0.01	94.73	5iA circle 4 c 2-2
78	38.90	1.90	13.84	1.17	9.72	0.06	18.85	0.67	0.09	0.11	0.19	9.00	0.63	0.01	94.87	5iA circle 4 c 2-3
79	38.86	1.50	13.36	0.64	9.71	0.03	19.17	0.66	0.08	0.09	0.17	9.25	0.68	0.02	93.93	5iA circle 4 r 2-1

Table Aya Phlogopite. (continued).

No.	SiO2	TiO2	Al2O3	Cr2O3	FeO	MnO	MgO	BaO	CaO	NiO	Na2O	K2O	F	Cl	Total	Comment
80	40.36	1.43	14.26	0.03	9.66	0.03	19.94	0.60	0.13	0.13	0.21	9.03	0.78	0.02	96.27	5iA circle 4 r 2-2
81	40.18	1.49	13.69	0.35	9.64	0.06	19.96	0.81	0.05	0.15	0.19	8.95	0.74	0.02	95.97	5iA circle 4 r 2-3
82	38.76	1.77	13.86	1.54	10.11	0.05	18.44	0.66	0.11	0.10	0.19	9.15	0.59	0.02	95.09	5iA circle 5 r 1-1
83	39.17	2.60	13.89	0.80	9.65	0.05	18.73	0.59	0.05	0.11	0.18	8.98	0.63	0.02	95.18	5iA circle 5 r 1-2
84	38.60	1.65	14.45	1.61	9.56	0.06	18.15	0.66	0.03	0.15	0.20	8.54	0.55	0.00	93.99	5iA circle 5 r 1-3
85	38.84	1.68	14.15	1.46	9.56	0.06	18.38	0.68	0.00	0.06	0.20	8.73	0.57	0.01	94.13	5iA circle 5 c 1-1
86	38.80	1.85	13.84	1.46	10.05	0.05	18.45	0.69	0.00	0.10	0.21	9.24	0.60	0.00	95.07	5iA circle 5 c 1-2
87	39.33	1.86	13.57	0.62	10.15	0.07	18.97	1.00	0.01	0.12	0.13	9.19	0.74	0.02	95.45	5iA circle 5 c 1-3
88	38.44	1.59	13.34	0.94	9.66	0.03	18.81	0.61	0.01	0.09	0.17	8.84	0.59	0.02	92.88	5iA circle 5 c 2-1
89	39.61	1.65	13.74	0.31	10.22	0.04	19.06	0.89	0.02	0.11	0.14	9.32	0.75	0.03	95.54	5iA circle 5 c 2-2
90	38.99	1.71	13.77	0.53	10.34	0.05	18.86	0.72	0.01	0.13	0.20	9.10	0.70	0.00	94.81	5iA circle 5 c 2-3
91	39.08	1.69	14.05	1.02	9.98	0.08	18.81	0.61	0.11	0.09	0.18	8.87	0.59	0.00	94.90	5iA circle 5 r 2-1
92	38.77	1.75	13.63	1.06	9.82	0.04	18.99	0.76	0.01	0.09	0.16	8.63	0.60	0.01	94.07	5iA circle 5 r 2-2
93	39.45	1.67	13.94	0.37	9.73	0.06	19.23	0.72	0.02	0.14	0.21	9.01	0.63	0.00	94.92	5iA circle 5 r 2-3
94	39.58	1.44	14.49	0.60	10.00	0.04	19.63	1.01	0.01	0.13	0.10	8.68	0.71	0.02	96.13	5iA circle 6 r 1-1
95	40.03	1.50	13.77	0.61	9.22	0.06	19.79	0.82	0.05	0.11	0.08	9.13	0.80	0.02	95.62	5iA circle 6 r 1-2
96	39.54	1.24	13.54	0.26	9.47	0.05	19.87	0.86	0.02	0.12	0.10	9.18	0.84	0.02	94.74	5iA circle 6 r 1-3
97	39.81	1.46	13.88	0.08	9.44	0.05	19.98	1.02	0.01	0.13	0.19	8.85	0.75	0.01	95.34	5iA circle 6 c 1-1
98	38.73	1.52	14.23	1.04	9.66	0.05	19.16	0.75	0.01	0.14	0.20	9.04	0.61	0.01	94.88	5iA circle 6 c 1-2
99	38.91	1.70	14.30	1.28	9.79	0.06	18.95	0.77	0.01	0.13	0.19	9.10	0.60	0.03	95.55	5iA circle 6 c 1-3
100	40.33	1.47	13.81	0.01	9.58	0.03	20.03	0.71	0.00	0.15	0.19	9.02	0.75	0.01	95.77	5iA circle 6 c 2-1
101	40.12	2.07	13.77	0.03	9.53	0.05	19.91	0.72	0.04	0.10	0.18	9.16	0.79	0.01	96.15	5iA circle 6 c 2-2
102	40.22	1.40	14.11	0.02	9.63	0.05	20.17	0.89	0.00	0.18	0.17	9.00	0.78	0.00	96.28	5iA circle 6 c 2-3
103	39.30	1.24	13.99	0.30	9.62	0.06	20.55	0.66	0.03	0.13	0.09	8.86	0.77	0.00	95.29	5iA circle 6 r 2-1
104	39.54	1.29	13.95	0.21	9.64	0.05	20.20	0.83	0.00	0.12	0.05	9.03	0.90	0.00	95.43	5iA circle 6 r 2-2
105	39.99	1.17	14.01	0.24	9.16	0.08	20.71	0.72	0.09	0.14	0.02	8.82	0.92	0.00	95.68	5iA circle 6 r 2-3
106	38.06	2.20	14.32	1.04	13.93	0.09	16.15	0.75	0.05	0.05	0.19	9.26	0.44	0.02	96.36	5j circle 1 r 1-1
107	38.87	1.97	14.53	0.66	13.77	0.04	16.83	0.65	0.01	0.02	0.23	9.24	0.50	0.02	97.13	5j circle 1 r 1-2
108	38.19	1.93	14.15	0.51	13.03	0.08	16.58	0.92	0.07	0.02	0.07	9.63	0.51	0.01	95.47	5j circle 1 r 1-3
109	37.74	2.15	13.98	0.81	13.35	0.09	16.83	0.57	0.02	0.08	0.18	8.43	0.44	0.02	94.51	5j circle 1 c 1-1
110	37.84	2.22	14.18	0.75	13.92	0.07	15.93	0.86	0.00	0.04	0.26	8.96	0.45	0.02	95.30	5j circle 1 c 1-2
111	38.10	2.21	14.20	0.70	13.98	0.07	16.37	0.79	0.02	0.06	0.19	9.03	0.46	0.03	96.00	5j circle 1 c 1-3
112	38.17	1.82	14.20	0.59	13.48	0.04	16.59	0.79	0.00	0.05	0.20	8.94	0.51	0.02	95.17	5j circle 1 c 2-1
113	37.99	1.90	14.43	0.64	13.73	0.07	16.55	0.76	0.01	0.06	0.18	9.18	0.46	0.04	95.80	5j circle 1 c 2-2
114	38.46	1.82	14.26	0.45	14.10	0.08	16.80	0.93	0.03	0.04	0.07	8.02	0.59	0.02	95.42	5j circle 1 c 2-3
115	38.51	1.85	14.40	0.39	13.35	0.08	16.99	0.73	0.02	0.00	0.13	8.68	0.52	0.03	95.46	5j circle 1 r 2-1
116	38.39	1.83	14.46	0.21	13.73	0.08	17.21	0.81	0.00	0.00	0.08	8.68	0.48	0.01	95.76	5j circle 1 r 2-2
117	39.00	1.85	14.43	0.35	13.53	0.06	17.07	0.85	0.00	0.00	0.11	8.68	0.62	0.04	96.30	5j circle 1 r 2-3

Table Aya Phlogopite. (continued).

No.	SiO2	TiO2	Al2O3	Cr2O3	FeO	MnO	MgO	BaO	CaO	NiO	Na2O	K2O	F	Cl	Total	Comment
118	39.11	1.80	14.23	0.05	12.89	0.08	17.89	0.81	0.01	0.01	0.12	8.56	0.65	0.02	95.94	5j circle 2 r 1-1
119	39.10	1.73	14.28	0.03	12.53	0.08	17.70	0.58	0.05	0.01	0.09	8.50	0.51	0.03	95.01	5j circle 2 r 1-2
120	39.39	1.89	14.46	0.10	12.97	0.09	17.68	1.06	0.05	0.04	0.14	8.54	0.59	0.02	96.75	5j circle 2 r 1-3
121	38.52	2.01	14.42	0.54	13.09	0.07	16.92	0.63	0.01	0.04	0.22	8.56	0.42	0.02	95.28	5j circle 2 c 1-1
122	38.40	1.91	14.11	0.43	12.80	0.09	17.03	0.64	0.01	0.04	0.21	8.59	0.36	0.01	94.47	5j circle 2 c 1-2
123	38.81	1.71	13.64	0.01	12.59	0.06	17.62	0.55	0.01	0.02	0.12	8.76	0.53	0.02	94.24	5j circle 2 c 1-3
124	38.77	2.08	14.25	0.70	13.90	0.08	16.60	0.74	0.01	0.05	0.20	8.18	0.40	0.01	95.80	5j circle 2 c 2-1
125	38.66	2.22	13.95	0.89	12.91	0.07	17.04	0.65	0.01	0.05	0.22	8.24	0.44	0.01	95.17	5j circle 2 c 2-2
126	38.79	2.08	14.11	0.07	13.08	0.08	17.24	0.98	0.05	0.04	0.22	8.12	0.47	0.03	95.16	5j circle 2 c 2-3
127	38.67	2.25	13.97	0.74	13.02	0.08	16.99	0.68	0.00	0.02	0.21	8.54	0.45	0.04	95.46	5j circle 2 r 2-1
128	38.87	2.01	13.83	0.09	13.06	0.08	16.94	0.75	0.01	0.06	0.14	8.66	0.60	0.02	94.85	5j circle 2 r 2-2
129	39.43	1.70	13.93	0.04	12.82	0.09	17.79	0.56	0.01	0.05	0.16	8.61	0.53	0.01	95.50	5j circle 2 r 2-3
130	38.43	1.88	14.38	0.46	13.52	0.06	16.56	0.66	0.09	0.01	0.18	8.35	0.42	0.03	94.86	5j circle 3 r 1-1
131	38.05	1.87	14.13	0.35	13.37	0.08	16.56	0.85	0.02	0.00	0.15	8.34	0.45	0.05	94.05	5j circle 3 r 1-2
132	37.94	1.61	14.32	0.16	13.59	0.08	16.77	0.78	0.09	0.00	0.05	8.53	0.53	0.02	94.24	5j circle 3 r 1-3
133	38.56	2.21	14.04	0.61	14.02	0.10	16.44	0.85	0.02	0.02	0.15	8.29	0.45	0.01	95.58	5j circle 3 c 1-1
134	38.56	2.27	14.11	0.58	14.01	0.10	16.49	0.74	0.01	0.00	0.14	8.98	0.51	0.02	96.29	5j circle 3 c 1-2
135	38.21	2.24	13.90	0.64	14.00	0.07	16.50	0.77	0.01	0.02	0.25	8.87	0.47	0.03	95.77	5j circle 3 c 1-3
136	38.08	2.19	14.08	0.59	13.57	0.07	16.60	0.81	0.01	0.04	0.19	9.02	0.50	0.02	95.55	5j circle 3 c 2-1
137	37.87	2.28	13.85	0.84	14.08	0.11	15.92	0.85	0.03	0.02	0.07	9.45	0.62	0.03	95.76	5j circle 3 c 2-2
138	37.76	2.05	14.30	0.76	13.34	0.08	16.26	0.71	0.02	0.01	0.25	9.12	0.46	0.01	94.92	5j circle 3 c 2-3
139	37.87	1.73	14.45	0.60	13.54	0.07	16.58	0.77	0.05	0.03	0.09	9.26	0.55	0.03	95.37	5j circle 3 r 2-1
140	37.52	1.93	14.33	0.79	13.26	0.08	16.63	0.80	0.07	0.04	0.21	8.78	0.50	0.03	94.76	5j circle 3 r 2-2
141	38.28	1.67	14.71	0.18	13.65	0.09	15.83	0.85	0.10	0.00	0.12	8.41	0.55	0.04	94.26	5j circle 3 r 2-3
142	38.10	1.87	14.03	0.12	13.08	0.06	17.26	1.03	0.03	0.01	0.16	9.40	0.61	0.03	95.53	5j circle 4 r 1-1
143	39.02	1.81	13.88	0.15	12.80	0.05	17.84	0.70	0.08	0.05	0.12	9.26	0.66	0.04	96.16	5j circle 4 r 1-2
144	38.23	1.86	14.45	0.88	13.17	0.05	16.74	0.67	0.01	0.05	0.21	9.11	0.48	0.04	95.74	5j circle 4 r 1-3
145	38.68	1.89	14.29	1.34	12.94	0.06	16.83	0.67	0.00	0.08	0.19	9.10	0.50	0.02	96.38	5j circle 4 c 1-1
146	38.37	1.85	14.32	0.63	13.04	0.06	16.94	0.72	0.00	0.10	0.22	8.98	0.53	0.00	95.54	5j circle 4 c 1-2
147	38.35	1.88	14.64	0.76	13.13	0.07	17.05	0.66	0.01	0.09	0.24	9.15	0.55	0.02	96.36	5j circle 4 c 1-3
148	38.22	1.99	14.31	0.62	13.24	0.05	16.69	0.87	0.00	0.05	0.15	9.37	0.53	0.02	95.89	5j circle 4 c 2-1
149	38.37	1.91	14.07	0.62	13.09	0.06	17.03	0.76	0.00	0.05	0.23	9.13	0.52	0.02	95.64	5j circle 4 c 2-2
150	38.11	1.91	13.97	0.62	13.52	0.11	17.09	0.68	0.01	0.07	0.18	8.99	0.51	0.03	95.57	5j circle 4 c 2-3
151	38.43	2.06	14.24	0.10	13.71	0.08	17.19	0.81	0.02	0.05	0.16	9.12	0.57	0.02	96.29	5j circle 4 r 2-1
152	38.34	1.83	14.08	0.10	12.86	0.08	17.15	0.80	0.05	0.05	0.09	9.43	0.58	0.02	95.21	5j circle 4 r 2-2
153	38.86	1.98	14.55	0.88	12.96	0.07	17.44	0.60	0.14	0.04	0.26	8.87	0.52	0.01	96.94	5j circle 4 r 2-3
418	39.07	1.93	14.06	1.66	10.35	0.10	18.30	0.79	0.02	0.12	0.18	8.71	0.52	0.02	95.60	5iA 1 c 1
419	38.71	1.86	13.86	1.52	10.42	0.06	17.96	0.59	0.05	0.09	0.22	8.97	0.52	0.01	94.62	5iA 1 c 2

Table Aya Phlogopite. (continued).

No.	SiO2	TiO2	Al2O3	Cr2O3	FeO	MnO	MgO	BaO	CaO	NiO	Na2O	K2O	F	Cl	Total	Comment
420	38.86	1.89	13.99	1.63	9.87	0.07	18.19	0.76	0.03	0.09	0.23	9.09	0.56	0.00	95.04	5iA 1 c 3
421	39.01	1.53	14.40	0.94	10.33	0.07	18.58	0.73	0.06	0.08	0.19	9.09	0.59	0.01	95.34	5iA 1 r 1
422	39.14	1.81	14.08	1.53	10.22	0.05	18.42	0.77	0.05	0.10	0.20	9.02	0.57	0.01	95.72	5iA 1 r 2
423	39.62	1.46	13.86	0.01	10.76	0.08	18.99	0.73	0.03	0.29	0.22	8.90	0.69	0.01	95.36	5iA 1 r 3
424	39.38	1.56	13.98	0.58	10.25	0.07	18.53	0.86	0.08	0.10	0.18	9.07	0.62	0.00	94.98	5iA 2 r 1
425	38.67	1.64	14.10	0.77	10.19	0.06	18.40	0.76	0.05	0.08	0.20	9.12	0.60	0.00	94.39	5iA 2 r 2
426	39.28	1.72	14.08	1.10	9.98	0.06	18.77	0.71	0.04	0.04	0.22	9.00	0.62	0.02	95.37	5iA 2 r 3
428	39.99	1.60	13.72	0.39	10.11	0.08	18.64	0.92	0.03	0.10	0.14	9.20	0.68	0.00	95.28	5iA 2 c 2
429	39.63	1.46	13.99	0.31	10.55	0.07	18.84	1.05	0.04	0.09	0.19	8.91	0.71	0.00	95.52	5iA 2 c 3
430	39.60	1.92	13.84	1.02	10.16	0.06	18.86	0.62	0.02	0.13	0.23	9.16	0.61	0.00	95.97	5iA 3 c 1
431	39.59	1.71	13.83	0.52	10.37	0.05	19.13	0.83	0.01	0.12	0.22	9.33	0.63	0.01	96.08	5iA 3 c 2
432	39.29	2.43	13.92	1.40	9.92	0.06	18.54	0.70	0.00	0.13	0.25	9.24	0.59	0.00	96.21	5iA 3 c 3
433	39.33	1.93	14.07	1.36	10.02	0.07	18.35	0.67	0.02	0.11	0.21	9.36	0.56	0.01	95.84	5iA 3 r 1
434	39.55	1.47	13.81	0.11	10.17	0.06	19.04	1.05	0.00	0.13	0.15	9.51	0.74	0.00	95.47	5iA 3 r 2
435	39.63	1.49	13.97	0.00	10.14	0.08	19.10	0.65	0.03	0.10	0.21	9.35	0.69	0.03	95.15	5iA 3 r 3
436	39.10	1.74	13.77	1.04	10.37	0.10	18.97	0.63	0.09	0.11	0.16	9.09	0.66	0.00	95.54	5iA 4 r 1 kinked
437	38.73	2.04	13.51	1.20	10.13	0.09	18.70	0.61	0.15	0.11	0.18	8.64	0.60	0.01	94.44	5iA 4 r 2 kinked
438	38.95	1.96	13.66	1.45	10.30	0.10	18.11	0.60	0.12	0.11	0.20	8.79	0.64	0.01	94.70	5iA 4 r 3 kinked
439	38.94	1.74	13.46	1.26	10.02	0.08	18.29	0.67	0.08	0.10	0.20	8.75	0.64	0.00	93.94	5iA 4 c 1 kinked
440	38.27	1.77	13.90	1.49	10.39	0.10	17.84	0.66	0.10	0.14	0.18	8.74	0.60	0.00	93.93	5iA 4 c 2 kinked
441	39.13	1.61	13.94	0.83	10.09	0.06	18.37	0.72	0.04	0.09	0.19	9.14	0.65	0.00	94.57	5iA 4 c 3 kinked
442	39.02	2.09	13.89	1.13	9.99	0.07	18.03	0.71	0.02	0.08	0.18	9.34	0.65	0.01	94.95	5iA 5 c 1 kinked
443	38.87	1.60	14.07	0.93	10.84	0.08	18.05	0.63	0.10	0.11	0.20	8.91	0.64	0.03	94.77	5iA 5 c 2 kinked
444	39.23	1.61	13.93	0.88	9.85	0.07	18.15	0.61	0.03	0.10	0.21	8.87	0.68	0.02	93.94	5iA 5 c 3 kinked
445	39.52	1.45	14.17	0.62	11.71	0.09	18.06	0.58	0.15	0.08	0.18	8.66	0.63	0.03	95.65	5iA 5 r 1 kinked
446	39.40	1.85	13.56	0.76	10.13	0.09	18.30	0.62	0.18	0.11	0.20	9.30	0.71	0.00	94.92	5iA 5 r 2 kinked
447	39.85	1.57	13.93	0.69	9.84	0.08	18.65	0.72	0.04	0.10	0.15	9.16	0.67	0.00	95.16	5iA 5 r 3 kinked
448	39.48	1.58	13.95	1.43	9.99	0.08	18.32	0.76	0.03	0.11	0.18	9.29	0.60	0.00	95.54	5iA 6 r 1
449	40.56	1.32	13.78	0.01	9.56	0.08	19.27	0.12	0.02	0.08	0.16	9.29	0.71	0.00	94.66	5iA 6 r 2
450	38.73	1.79	13.98	1.37	10.14	0.07	17.92	0.79	0.02	0.12	0.21	9.03	0.60	0.02	94.51	5iA 6 r 3
6c	39.81	1.58	13.60	0.18	10.08	0.08	18.87	0.92	0.00	0.11	0.14	9.15	0.78	0.00	94.96	5iA 6 c 3
453	38.65	1.82	13.72	1.49	10.28	0.09	17.92	0.92	0.04	0.08	0.22	8.79	0.63	0.00	94.39	5iA 7 c 1
454	39.09	1.67	13.60	1.28	9.98	0.07	18.43	0.83	0.05	0.12	0.18	9.15	0.67	0.01	94.84	5iA 7 c 2
455	38.71	1.76	13.85	1.05	10.08	0.05	17.94	1.08	0.03	0.11	0.20	8.82	0.69	0.01	94.08	5iA 7 c 3
456	39.13	1.77	13.96	0.91	10.41	0.12	18.07	0.75	0.10	0.08	0.20	8.97	0.63	0.00	94.84	5iA 7 r 1
457	39.05	1.80	13.78	1.23	10.12	0.09	18.04	0.61	0.09	0.11	0.20	8.72	0.61	0.00	94.18	5iA 7 r 2
458	38.60	2.33	13.54	1.12	10.02	0.10	17.98	0.59	0.12	0.12	0.17	8.77	0.64	0.00	93.85	5iA 7 r 3
462	40.40	1.28	13.89	0.01	9.79	0.08	20.13	0.12	0.07	0.16	0.22	9.09	0.63	0.02	95.62	5iA 8 c 1z

Table Aya Phlogopite. (continued).

No.	SiO2	TiO2	Al2O3	Cr2O3	FeO	MnO	MgO	BaO	CaO	NiO	Na2O	K2O	F	Cl	Total	Comment
463	40.42	1.30	13.75	0.02	9.71	0.08	19.89	0.13	0.09	0.15	0.20	8.75	0.66	0.02	94.90	5iA 8 c 2z
464	39.40	1.13	13.61	0.05	9.30	0.13	21.42	0.20	0.09	0.11	0.19	7.44	0.64	0.03	93.47	5iA 8 c 3z
465	32.03	0.97	15.28	0.04	12.62	0.37	24.41	0.00	0.15	0.10	0.07	0.75	0.47	0.01	87.06	5iA 9 c 1z
466	39.94	1.25	13.57	0.04	9.67	0.09	19.89	0.12	0.07	0.14	0.17	9.05	0.47	0.02	94.28	5iA 9 c 2z
467	38.19	1.05	13.78	0.00	9.55	0.15	22.40	0.10	0.11	0.10	0.14	5.84	0.64	0.02	91.80	5iA 9 c 3z
468	39.49	1.08	13.67	0.05	10.10	0.12	20.82	0.10	0.14	0.11	0.20	7.82	0.65	0.03	94.12	5iA 9 r 1z
469	39.37	1.04	13.34	0.03	9.65	0.12	21.47	0.27	0.11	0.15	0.16	7.69	0.65	0.02	93.79	5iA 9 r 2z
470	40.61	1.23	13.84	0.07	9.22	0.08	19.59	0.70	0.09	0.13	0.06	9.27	0.81	0.03	95.37	5iA 9 r 3z
471	38.04	2.93	13.49	1.82	9.89	0.09	18.17	0.63	0.16	0.16	0.22	8.52	0.56	0.05	94.48	5iA 10r 1
472	39.20	1.58	14.32	1.24	10.07	0.09	18.35	0.85	0.08	0.18	0.22	9.15	0.59	0.02	95.66	5iA 10 r 2
473	38.48	1.59	13.67	1.77	10.03	0.11	18.12	0.72	0.13	0.17	0.12	8.91	0.57	0.04	94.17	5iA 10 r 3
474	39.28	1.66	13.95	1.64	9.97	0.11	18.62	0.56	0.07	0.15	0.21	8.98	0.60	0.02	95.55	5iA 10 c 1
475	38.80	1.76	14.12	2.03	10.21	0.09	18.29	0.77	0.11	0.19	0.21	9.12	0.56	0.03	96.03	5iA 10 c 2
476	39.16	2.31	13.93	1.10	9.93	0.10	18.65	0.76	0.07	0.16	0.20	8.95	0.60	0.02	95.68	5iA 10 c 3
477	38.97	1.71	13.74	1.38	9.83	0.11	18.66	0.69	0.22	0.15	0.22	8.84	0.54	0.03	94.83	5iA 11 kinked
478	39.90	1.75	14.09	1.36	9.81	0.09	19.28	0.69	0.20	0.16	0.25	8.67	0.69	0.04	96.68	5iA 11 kinked
479	38.84	1.73	14.49	1.57	10.33	0.06	18.23	0.65	0.00	0.17	0.19	9.07	0.54	0.01	95.65	5iA 12 c 1
480	38.98	1.79	13.99	1.26	9.94	0.04	18.38	0.79	0.02	0.10	0.21	9.26	0.59	0.00	95.10	5iA 12 c 2
481	39.58	1.68	14.18	1.20	9.90	0.06	18.75	0.74	0.02	0.14	0.21	9.20	0.64	0.02	96.05	5iA 12 c 3
482	39.21	1.70	13.99	1.38	10.18	0.05	18.44	0.68	0.02	0.14	0.21	9.10	0.61	0.00	95.46	5iA 12 r 1
483	39.17	1.65	14.30	1.37	10.14	0.05	18.48	0.78	0.03	0.13	0.20	8.78	0.58	0.02	95.43	5iA 12 r 2
484	39.75	1.51	14.06	0.40	10.02	0.04	19.53	1.06	0.04	0.13	0.21	9.10	0.79	0.03	96.34	5iA 12 r 3
485	38.61	1.34	13.45	0.00	10.80	0.07	20.29	0.52	0.05	0.15	0.15	7.63	0.64	0.02	93.43	5ib 1 r 1
486	38.51	1.56	13.90	0.08	11.20	0.07	18.58	1.05	0.02	0.12	0.19	9.17	0.75	0.02	94.89	5ib 1 r 2
487	38.59	1.89	14.42	0.96	11.00	0.05	18.21	0.65	0.02	0.11	0.26	9.26	0.60	0.01	95.78	5ib 1 r 3
488	38.25	1.88	14.69	0.78	10.84	0.04	18.41	0.69	0.00	0.13	0.24	9.49	0.56	0.00	95.75	5ib 1 c 1
489	38.73	1.85	14.26	0.63	10.65	0.07	18.48	0.89	0.02	0.12	0.22	9.24	0.67	0.01	95.54	5ib 1 c 2
490	39.33	1.80	14.38	0.54	10.86	0.06	18.53	0.72	0.01	0.14	0.23	9.37	0.58	0.01	96.29	5ib 1 c 3
491	38.49	1.86	14.51	1.27	10.78	0.07	18.00	0.64	0.03	0.11	0.26	9.40	0.55	0.01	95.75	5ib 2 c 1
492	38.90	1.75	13.93	0.73	11.22	0.09	18.45	0.99	0.04	0.10	0.09	9.40	0.75	0.03	96.14	5ib 2 c 2
493	38.26	1.89	14.10	1.46	10.88	0.04	18.04	0.60	0.05	0.10	0.21	9.25	0.51	0.01	95.15	5ib 2 c 3
494	38.04	1.97	14.38	1.62	11.02	0.05	17.98	0.63	0.10	0.11	0.23	9.29	0.52	0.02	95.72	5ib 2 r 1
495	39.87	1.43	13.90	0.16	10.27	0.07	19.55	1.05	0.05	0.14	0.20	8.65	0.71	0.04	95.79	5ib 2 r 2
496	38.26	1.78	14.59	1.25	10.79	0.07	18.07	0.56	0.09	0.12	0.22	9.58	0.49	0.01	95.67	5ib 2 r 3
497	38.81	1.93	13.71	1.50	10.72	0.04	18.27	0.63	0.02	0.10	0.21	9.15	0.68	0.00	95.49	5ib 3 r 1
498	38.72	1.88	13.97	1.70	10.85	0.05	18.15	0.76	0.04	0.13	0.23	9.31	0.58	0.01	96.14	5ib 3 r 2
499	37.94	1.86	14.21	1.88	10.90	0.07	17.75	0.83	0.03	0.09	0.17	8.76	0.55	0.00	94.81	5ib 3 r 3
500	37.33	2.04	14.38	1.98	11.01	0.07	17.57	0.69	0.00	0.08	0.24	9.29	0.54	0.00	94.99	5ib 3 c 1

Table Aya Phlogopite. (continued).

No.	SiO2	TiO2	Al2O3	Cr2O3	FeO	MnO	MgO	BaO	CaO	NiO	Na2O	K2O	F	Cl	Total	Comment
501	37.74	2.06	14.12	1.90	10.78	0.06	17.45	0.69	0.03	0.09	0.22	9.32	0.58	0.01	94.80	5ib 3 c 2
502	37.34	1.97	14.47	1.82	10.88	0.06	17.81	0.65	0.03	0.10	0.22	9.19	0.59	0.00	94.88	5ib 3 c 3
503	38.54	1.19	13.58	0.26	10.21	0.07	20.13	0.27	0.05	0.05	0.16	8.35	0.69	0.01	93.27	5ib 4 c 1
504	38.33	1.31	13.55	0.21	10.34	0.10	19.80	0.43	0.07	0.05	0.16	8.31	0.82	0.01	93.12	5ib 4 c 2
505	38.79	1.50	14.15	0.39	10.45	0.06	18.86	0.94	0.10	0.09	0.06	9.68	0.86	0.01	95.58	5ib 4 r 1
506	36.91	1.29	14.31	0.26	11.13	0.16	20.39	0.61	0.11	0.07	0.13	6.98	0.67	0.03	92.76	5ib 4 r 2
507	38.55	1.86	14.26	1.06	10.50	0.09	18.15	0.64	0.06	0.11	0.19	9.21	0.61	0.00	95.02	5ib 5 r 1
508	38.09	1.72	14.01	0.54	11.12	0.09	17.92	1.04	0.03	0.09	0.15	8.90	0.64	0.01	94.09	5ib 5 r 2
509	38.80	1.72	14.27	0.29	10.59	0.05	18.52	0.72	0.08	0.06	0.18	9.00	0.63	0.01	94.66	5ib 5 r 3
510	38.53	1.85	14.15	0.70	10.56	0.08	18.04	0.66	0.02	0.07	0.21	9.27	0.61	0.00	94.48	5ib 5 c 1
511	38.20	1.80	14.47	0.80	10.84	0.06	17.85	0.66	0.02	0.07	0.22	9.34	0.60	0.01	94.68	5ib 5 c 2
512	38.42	1.81	14.53	1.01	10.81	0.06	17.92	0.71	0.02	0.08	0.19	9.28	0.53	0.00	95.15	5ib 5 c 3
513	37.34	1.77	14.69	1.04	11.00	0.09	18.17	0.76	0.01	0.10	0.17	9.44	0.61	0.01	94.93	5ib6 c 1
514	37.15	1.86	14.82	1.88	10.59	0.08	17.75	0.53	0.00	0.11	0.19	9.32	0.48	0.00	94.54	5ib 6 c 2
515	37.44	1.85	14.75	1.55	10.33	0.07	17.75	0.68	0.00	0.11	0.25	9.37	0.50	0.00	94.44	5ib 6 c 3
516	36.97	1.86	14.59	1.69	10.98	0.09	17.66	0.65	0.05	0.08	0.21	9.38	0.50	0.00	94.49	5ib 6 r 1
517	38.02	1.81	14.80	1.55	10.49	0.05	18.10	0.63	0.02	0.09	0.19	9.36	0.54	0.03	95.41	5ib 6 r 2
518	39.08	1.43	14.08	0.29	10.19	0.08	19.24	0.89	0.03	0.07	0.11	8.99	0.82	0.00	94.95	5ib 6 r 3
725	38.84	2.06	14.92	0.00	15.03	0.09	15.85	0.93	0.01	0.00	0.18	8.58	0.46	0.03	96.76	5d 1 c 1
726	37.40	1.99	14.75	0.00	14.42	0.08	15.70	1.16	0.04	0.04	0.19	8.65	0.43	0.01	94.66	5d 1 c 2
727	38.44	1.95	14.59	0.00	14.23	0.07	16.33	0.87	0.06	0.03	0.16	8.96	0.57	0.03	96.04	5d 1 c 3
728	38.18	2.21	14.54	0.00	14.58	0.08	15.73	0.95	0.03	0.03	0.18	8.70	0.46	0.05	95.51	5d 1 r 1
729	38.25	1.94	14.62	0.00	14.35	0.07	15.78	1.07	0.07	0.00	0.18	8.65	0.44	0.04	95.26	5d 1 r 2
730	38.59	2.02	14.60	0.00	14.29	0.07	16.09	0.87	0.06	0.00	0.20	8.68	0.49	0.02	95.77	5d 1 r 3
731	38.30	1.95	14.79	0.00	14.72	0.09	15.80	1.05	0.11	0.01	0.15	8.96	0.46	0.03	96.21	5d 2 r 1
732	37.90	1.78	15.03	0.00	14.69	0.07	15.50	0.97	0.10	0.04	0.14	9.02	0.47	0.03	95.54	5d 2 r 2
733	38.06	1.75	14.55	0.00	14.44	0.08	16.01	0.83	0.19	0.02	0.11	8.82	0.48	0.03	95.15	5d 2 r 3
734	38.11	2.06	14.88	0.00	14.78	0.08	15.98	1.04	0.01	0.02	0.14	8.94	0.51	0.03	96.36	5d 2 c1
735	38.00	2.04	14.56	0.00	14.72	0.09	15.89	1.01	0.02	0.06	0.07	9.00	0.54	0.03	95.79	5d 2 c2
736	37.79	2.02	14.86	0.00	14.62	0.09	15.89	1.05	0.03	0.00	0.18	8.35	0.48	0.02	95.16	5d 2 c3
737	38.30	2.09	14.87	0.00	14.77	0.08	15.58	1.09	0.12	0.02	0.24	8.60	0.52	0.06	96.10	5d 3 c1
738	38.04	1.98	14.95	0.00	15.01	0.09	16.05	1.09	0.17	0.03	0.12	8.69	0.57	0.04	96.59	5d 3 c2
739	38.71	1.99	14.65	0.00	14.59	0.08	16.11	0.90	0.07	0.03	0.18	8.46	0.47	0.03	96.06	5d 3 c3
740	38.80	1.90	14.24	0.00	14.43	0.06	16.04	0.84	0.14	0.00	0.11	8.64	0.53	0.03	95.53	5d 3 r1
741	38.32	1.95	15.01	0.00	14.55	0.09	15.89	1.03	0.14	0.03	0.20	8.46	0.50	0.05	96.00	5d 3 r2
742	38.81	1.64	14.22	0.00	14.23	0.09	16.39	0.71	0.21	0.01	0.11	9.01	0.61	0.05	95.81	5d 3 r3
743	38.07	1.88	14.52	0.00	14.46	0.07	16.22	0.82	0.16	0.01	0.07	9.13	0.65	0.04	95.81	5d 4 r1
744	38.03	1.80	14.29	0.00	14.17	0.08	16.01	0.78	0.37	0.00	0.14	9.17	0.56	0.04	95.19	5d 4 r2

Table Aya Phlogopite. (continued).

No.	SiO2	TiO2	Al2O3	Cr2O3	FeO	MnO	MgO	BaO	CaO	NiO	Na2O	K2O	F	Cl	Total	Comment
745	38.78	1.86	14.91	0.00	14.00	0.05	15.13	1.03	0.12	0.02	0.18	8.17	0.39	0.05	94.52	5d 4 r3
746	38.38	2.00	14.26	0.00	13.85	0.06	15.20	0.89	0.01	0.01	0.21	8.67	0.40	0.05	93.81	5d 4 c1
747	38.13	2.01	14.54	0.00	14.07	0.04	14.98	0.97	0.11	0.02	0.19	8.55	0.45	0.05	93.89	5d 4 c2
748	38.35	2.03	14.87	0.00	14.02	0.04	15.28	1.05	0.09	0.00	0.24	8.35	0.45	0.05	94.60	5d 4 c3
749	39.07	2.15	15.33	0.01	14.45	0.05	15.39	1.15	0.11	0.04	0.17	6.53	0.47	0.02	94.72	5d 5 c1
750	39.61	2.06	14.45	0.00	14.65	0.04	16.17	1.08	0.03	0.03	0.19	8.24	0.42	0.02	96.81	5d 5 c2
751	38.44	2.12	13.86	0.00	14.63	0.05	15.89	1.08	0.01	0.00	0.16	8.40	0.46	0.04	94.94	5d 5 c3
752	38.82	2.07	13.96	0.00	14.27	0.06	16.18	0.98	0.01	0.00	0.19	8.49	0.43	0.03	95.31	5d 5 c4
753	38.54	2.16	14.13	0.02	14.80	0.06	16.15	1.13	0.05	0.02	0.19	8.27	0.42	0.04	95.79	5d 5 r1
754	38.22	1.79	14.05	0.00	14.78	0.07	16.05	0.84	0.04	0.06	0.11	8.51	0.52	0.02	94.82	5d 5 r2
755	38.25	2.08	14.03	0.00	14.86	0.04	15.96	1.23	0.07	0.02	0.18	8.26	0.45	0.03	95.25	5d 5 r3
756	38.31	1.86	14.00	0.00	14.81	0.07	16.06	1.34	0.01	0.03	0.18	8.31	0.49	0.04	95.29	5d 6 r1
757	39.13	1.40	13.63	0.00	13.78	0.04	16.72	0.66	0.08	0.00	0.07	8.72	0.64	0.04	94.63	5d 6 r2
758	38.88	1.88	13.74	0.00	14.47	0.07	16.30	0.79	0.09	0.00	0.11	8.79	0.55	0.02	95.40	5d 6 r3
759	38.25	2.10	14.13	0.03	14.87	0.06	15.84	1.23	0.03	0.02	0.22	8.15	0.45	0.02	95.21	5d 6 c1
760	38.27	2.09	14.02	0.02	15.11	0.05	15.66	1.10	0.05	0.04	0.16	8.30	0.50	0.05	95.26	5d 6 c2
761	37.95	1.99	13.97	0.01	15.11	0.04	15.68	1.15	0.03	0.04	0.13	8.66	0.53	0.02	95.10	5d 6 c3
762	38.71	1.89	14.20	0.00	14.64	0.06	16.10	1.02	0.03	0.02	0.20	8.31	0.46	0.04	95.47	5d 7 c1
763	38.49	1.96	14.00	0.00	14.65	0.06	16.04	1.02	0.00	0.02	0.18	8.41	0.48	0.05	95.13	5d 7 c2
764	38.90	1.92	13.95	0.00	14.55	0.07	15.95	0.94	0.06	0.01	0.21	8.23	0.49	0.05	95.09	5d 7 c3
765	38.42	1.97	14.18	0.01	14.97	0.05	15.78	1.09	0.03	0.00	0.22	8.21	0.44	0.04	95.21	5d 7 r1
766	39.23	1.66	13.66	0.00	14.70	0.06	16.21	0.74	0.05	0.01	0.18	8.25	0.46	0.04	95.04	5d 7 r2
767	39.16	1.87	13.46	0.00	14.45	0.04	16.18	0.85	0.03	0.02	0.17	8.39	0.51	0.02	94.94	5d 7 r3
768	38.81	1.78	13.90	0.01	14.07	0.07	16.47	0.75	0.04	0.02	0.13	8.98	0.56	0.03	95.37	5d 8 1
769	39.92	1.68	13.43	0.00	14.27	0.06	17.03	0.58	0.02	0.00	0.09	8.57	0.59	0.02	96.01	5d 8 2
770	40.23	1.71	14.00	0.00	14.29	0.06	16.65	0.62	0.06	0.03	0.09	7.82	0.61	0.03	95.93	5d 8 3
771	37.83	1.61	13.94	0.00	14.53	0.08	16.41	0.67	0.01	0.04	0.10	8.84	0.61	0.04	94.44	5d 9 1
772	38.91	1.52	14.16	0.04	13.82	0.07	16.56	0.73	0.10	0.02	0.14	8.63	0.52	0.06	95.04	5d 10 1
773	38.48	1.66	14.52	0.03	14.03	0.07	16.13	1.08	0.22	0.02	0.48	8.61	0.48	0.12	95.70	5d 10 2
774	38.69	2.06	14.41	0.78	13.99	0.04	15.92	0.81	0.00	0.05	0.26	8.27	0.49	0.06	95.60	5d 10 c1
775	37.75	2.09	14.51	1.31	14.45	0.08	15.25	0.80	0.03	0.04	0.21	8.41	0.44	0.07	95.24	5d 10 c2
776	38.29	2.12	14.25	0.96	14.24	0.05	15.73	0.82	0.01	0.03	0.23	8.41	0.44	0.05	95.43	5d 10 c3
777	38.75	1.95	14.38	0.50	14.31	0.06	16.38	0.70	0.02	0.03	0.19	8.21	0.44	0.04	95.77	5d 10 r1
778	38.79	2.12	14.61	0.83	14.36	0.06	15.84	0.75	0.01	0.02	0.24	8.30	0.44	0.04	96.21	5d 10 r2
779	38.33	2.07	14.40	1.43	14.31	0.07	15.61	0.77	0.08	0.01	0.26	8.19	0.49	0.04	95.84	5d 10 r3
780	38.10	1.79	14.50	0.75	14.15	0.05	16.00	0.82	0.09	0.05	0.19	8.27	0.49	0.05	95.08	5d 11 r1
781	37.54	1.91	14.67	0.67	14.45	0.07	15.55	0.96	0.12	0.01	0.24	8.26	0.48	0.06	94.77	5d 11 r2
782	37.56	1.80	14.53	0.45	14.25	0.06	15.80	0.82	0.10	0.03	0.21	8.27	0.49	0.03	94.19	5d 11 r3

Table Aya Phlogopite. (continued).

No.	SiO2	TiO2	Al2O3	Cr2O3	FeO	MnO	MgO	BaO	CaO	NiO	Na2O	K2O	F	Cl	Total	Comment
783	29.95	1.32	16.12	0.04	13.84	0.34	22.71	0.00	0.18	0.00	0.10	0.22	0.38	0.07	85.10	5d 11 r4 alt
784	38.05	1.87	14.81	1.12	13.95	0.04	15.77	0.72	0.05	0.02	0.22	8.36	0.49	0.04	95.27	5d 11 c1
785	37.76	1.91	14.70	0.90	14.42	0.03	15.45	0.77	0.05	0.07	0.24	8.22	0.41	0.05	94.79	5d 11 c2
786	37.73	1.98	14.30	0.51	14.43	0.07	15.51	1.03	0.03	0.05	0.16	8.35	0.50	0.08	94.50	5d 11 c3
787	38.59	1.90	14.38	0.00	14.28	0.06	16.15	0.83	0.03	0.07	0.24	8.28	0.54	0.04	95.13	5d 12 c1
788	37.45	1.74	14.51	0.01	14.52	0.07	15.90	0.74	0.03	0.06	0.19	8.27	0.41	0.07	93.78	5d 12 c2
789	38.88	1.74	14.19	0.06	14.17	0.05	16.13	0.72	0.01	0.03	0.25	8.32	0.49	0.06	94.89	5d 12 c3
790	68.73	0.00	17.92	0.00	0.22	0.04	0.00	0.02	0.00	0.04	0.02	14.44	0.00	0.01	101.43	5d 12 c4 alt
791	65.74	0.02	17.52	0.01	0.25	0.03	0.00	0.01	0.02	0.07	0.06	16.12	0.00	0.00	99.83	5d 12 c5 alt
792	39.13	1.82	14.17	0.09	13.81	0.12	16.91	0.72	0.10	0.10	0.15	8.61	0.71	0.04	96.16	5d 12 r1
793	39.08	1.82	14.39	0.11	13.66	0.12	16.98	0.74	0.16	0.12	0.25	8.50	0.72	0.05	96.38	5d 12 r2
794	39.13	1.80	14.79	0.17	14.66	0.12	16.22	0.75	0.10	0.13	0.23	8.65	0.67	0.08	97.18	5d 13 1
795	38.92	1.82	15.16	0.10	14.78	0.10	15.93	0.78	0.10	0.09	0.23	8.65	0.66	0.05	97.07	5d 13 2
796	38.09	1.96	14.98	0.13	15.15	0.13	16.23	0.79	0.13	0.09	0.21	8.49	0.68	0.04	96.80	5d 13 3
797	39.22	1.81	14.41	0.23	14.05	0.08	16.36	1.02	0.07	0.10	0.21	8.10	0.63	0.06	96.08	5d 14 1
798	38.75	1.84	14.65	0.20	14.15	0.14	16.12	1.02	0.03	0.10	0.16	8.73	0.66	0.05	96.31	5d 14 2
799	38.14	1.99	14.60	0.62	14.00	0.13	15.64	0.86	0.02	0.12	0.20	9.13	0.63	0.02	95.82	5d 15 c1
800	38.62	2.16	14.57	1.10	14.56	0.09	15.47	0.74	0.04	0.11	0.18	8.71	0.54	0.02	96.67	5d 15 c2
801	38.32	2.09	14.65	0.75	14.06	0.11	15.69	0.83	0.03	0.10	0.15	9.03	0.62	0.04	96.18	5d 15 c3
802	38.69	1.80	14.46	0.14	13.97	0.10	16.13	0.89	0.06	0.12	0.04	9.61	0.83	0.05	96.50	5d 15 r1
803	38.90	1.90	14.33	0.27	14.14	0.13	16.01	0.77	0.14	0.13	0.13	9.02	0.74	0.04	96.32	5d 15 r2
804	38.90	1.82	14.60	0.18	14.15	0.15	16.24	0.87	0.14	0.08	0.15	9.04	0.65	0.03	96.70	5d 15 r3
805	38.63	1.75	14.85	0.56	14.08	0.10	16.04	0.87	0.04	0.10	0.21	8.74	0.64	0.06	96.38	5d 16 1
806	38.02	1.84	14.19	0.45	14.44	0.10	16.07	0.85	0.08	0.15	0.17	9.52	0.74	0.17	96.43	5d 16 2
807	38.63	1.82	14.40	0.08	13.99	0.11	16.36	1.12	0.16	0.12	0.17	8.51	0.61	0.03	95.85	5d 17 1
808	38.78	1.71	14.52	0.07	14.03	0.10	16.39	0.82	0.09	0.12	0.15	8.95	0.69	0.04	96.15	5d 17 2
809	39.38	1.69	14.13	0.16	13.88	0.12	16.89	0.93	0.04	0.13	0.17	8.42	0.70	0.04	96.37	5d 18 1
810	40.31	1.71	14.20	0.00	14.32	0.08	16.15	0.97	0.09	0.00	0.15	7.72	0.59	0.02	96.04	5d 18 2
811	38.74	1.90	14.33	0.00	14.34	0.08	15.29	0.93	0.01	0.01	0.15	8.75	0.45	0.01	94.80	5d 19 1
812	39.29	1.92	14.72	0.00	14.13	0.08	15.78	0.97	0.00	0.04	0.19	8.10	0.55	0.02	95.55	5d 19 2
813	38.59	1.88	14.61	0.00	14.22	0.08	15.52	1.12	0.01	0.02	0.18	8.30	0.52	0.04	94.87	5d 19 3
814	38.81	1.86	14.74	0.00	14.88	0.08	15.21	1.07	0.05	0.04	0.27	8.42	0.52	0.05	95.76	5d 20 1
815	39.09	1.84	14.29	0.00	14.30	0.05	15.43	0.83	0.06	0.04	0.26	8.20	0.51	0.05	94.73	5d 20 2
816	37.65	1.86	14.57	1.17	15.95	0.08	14.34	0.84	0.09	0.06	0.21	8.12	0.40	0.02	95.19	5d 21 1
817	37.73	1.99	14.26	0.99	15.07	0.09	14.55	0.83	0.02	0.01	0.19	8.47	0.48	0.04	94.50	5d 21 2
818	38.11	1.78	14.71	0.66	14.38	0.08	15.33	0.83	0.05	0.01	0.22	8.60	0.50	0.04	95.08	5d 21 3
819	38.93	1.74	14.16	0.00	14.44	0.09	15.21	0.93	0.07	0.05	0.12	8.57	0.52	0.04	94.63	5d 22 1
820	38.25	1.96	14.21	0.00	14.50	0.08	14.96	1.22	0.05	0.03	0.20	8.57	0.47	0.02	94.31	5d 22 2

Table Aya Phlogopite. (continued).

No.	SiO2	TiO2	Al2O3	Cr2O3	FeO	MnO	MgO	BaO	CaO	NiO	Na2O	K2O	F	Cl	Total	Comment
821	0.03	0.00	0.00	0.00	0.65	0.26	0.06	0.00	58.85	0.00	0.00	0.07	0.00	0.00	59.93	5d 23 1 alt
822	0.02	0.01	0.00	0.00	0.34	0.30	0.40	0.00	58.70	0.00	0.00	0.11	0.00	0.01	59.90	5d 23 2 alt
823	0.00	0.01	0.01	0.00	1.01	0.69	0.31	0.00	60.10	0.02	0.02	0.06	0.00	0.01	62.22	5d 23 3 alt
824	38.39	2.02	14.44	0.00	14.38	0.07	15.67	0.91	0.01	0.00	0.17	8.45	0.52	0.02	94.83	5d 24 1
825	38.72	1.72	14.14	0.00	14.17	0.10	15.83	1.01	0.11	0.03	0.21	8.19	0.51	0.03	94.54	5d 24 2
826	38.48	1.81	14.41	0.00	14.39	0.10	15.79	1.15	0.03	0.01	0.14	8.69	0.56	0.01	95.35	5d 24 3
827	38.27	1.86	14.64	0.00	14.45	0.06	15.48	0.87	0.05	0.07	0.14	8.69	0.55	0.03	94.91	5d 25 1
828	38.43	1.76	14.17	0.00	15.16	0.07	15.66	0.83	0.05	0.00	0.07	8.66	0.66	0.04	95.26	5d 25 2
829	38.43	1.88	14.23	0.00	14.76	0.06	15.18	0.82	0.03	0.04	0.19	8.48	0.56	0.03	94.44	5d 26 1
830	39.39	1.89	14.62	0.00	14.62	0.05	15.88	0.94	0.05	0.00	0.18	8.43	0.47	0.05	96.35	5d 26 2
831	30.08	1.33	16.63	0.46	15.10	0.56	20.23	0.00	0.16	0.00	0.07	0.14	0.26	0.03	84.95	5fb 1 1 alt
832	30.29	1.31	16.17	0.57	16.04	0.51	19.66	0.01	0.18	0.00	0.09	0.35	0.29	0.04	85.37	5fb 1 2 alt
833	29.39	1.39	16.74	0.41	15.25	0.60	20.38	0.00	0.15	0.00	0.07	0.22	0.26	0.03	84.75	5fb 1 3 alt
834	29.96	1.34	16.72	0.87	15.70	0.57	19.90	0.00	0.19	0.00	0.09	0.20	0.28	0.03	85.72	5fb 2 1 alt
835	30.10	1.52	16.15	1.14	15.47	0.53	19.82	0.04	0.12	0.00	0.08	0.72	0.25	0.04	85.87	5fb 2 2 alt
836	30.30	1.45	15.90	0.79	17.05	0.47	19.50	0.01	0.16	0.00	0.07	0.85	0.29	0.03	86.73	5fb 2 3 alt
837	29.41	1.28	14.33	0.23	23.27	0.20	18.11	0.04	0.23	0.00	0.06	0.35	0.32	0.05	87.72	5fb 3 1 alt
838	29.79	1.48	15.16	0.65	17.45	0.47	19.82	0.02	0.21	0.00	0.08	0.42	0.29	0.05	85.76	5fb 3 2 alt
839	29.99	1.23	16.59	0.39	15.96	0.62	20.20	0.00	0.24	0.00	0.10	0.33	0.37	0.03	85.88	5fb 4 1 alt
840	30.27	1.31	16.37	0.54	16.36	0.51	20.01	0.00	0.23	0.00	0.08	0.20	0.29	0.05	86.09	5fb 4 2 alt
841	37.31	1.82	14.07	0.75	18.34	0.05	13.30	0.70	0.08	0.00	0.15	8.57	0.30	0.06	95.36	5fb 5 c1
842	37.49	1.83	14.25	0.79	18.06	0.04	13.65	0.60	0.18	0.00	0.22	8.37	0.35	0.06	95.72	5fb 5 c2
843	37.64	1.69	14.09	0.63	17.86	0.01	14.00	0.71	0.11	0.01	0.19	8.34	0.40	0.04	95.55	5fb 5 c3
844	37.23	1.69	13.87	0.08	18.57	0.10	14.02	0.69	0.23	0.00	0.11	8.90	0.51	0.07	95.83	5fb 5 r1
845	37.78	1.69	14.02	0.08	17.40	0.06	13.80	0.61	0.16	0.04	0.18	9.04	0.54	0.06	95.21	5fb 5 r2
846	37.57	1.83	14.25	0.45	18.19	0.08	13.47	0.74	0.10	0.02	0.18	8.66	0.40	0.05	95.80	5fb 5 r3
847	37.79	1.81	13.62	0.01	18.26	0.08	13.74	0.63	0.07	0.03	0.06	9.15	0.44	0.08	95.56	5fb 6 1
848	36.58	1.81	13.71	0.05	18.91	0.08	14.50	0.62	0.04	0.06	0.04	8.35	0.46	0.07	95.06	5fb 6 2
849	29.45	1.35	16.24	0.69	17.08	0.61	18.81	0.01	0.26	0.00	0.11	0.08	0.27	0.06	84.89	5fb 7 1 alt
850	30.22	1.50	16.71	0.88	17.67	0.61	19.34	0.03	0.18	0.00	0.09	0.21	0.23	0.04	87.60	5fb 7 2 alt
851	30.25	1.23	16.58	0.20	16.88	0.63	19.53	0.00	0.35	0.05	0.12	0.09	0.25	0.10	86.13	5fb 8 c1 alt
852	29.61	1.19	17.18	0.06	18.00	0.92	18.68	0.03	0.26	0.05	0.18	0.10	0.34	0.14	86.55	5fb 8 c2 alt
853	36.22	1.54	14.06	0.20	18.60	0.11	13.65	0.66	0.20	0.10	0.20	8.57	0.36	0.07	94.36	5fb 8 r1 alt
854	35.89	1.64	13.78	0.25	19.04	0.10	14.77	0.48	0.21	0.11	0.19	7.40	0.37	0.07	94.12	5fb 8 r2 alt
855	37.15	1.75	13.80	0.17	18.84	0.10	14.52	0.52	0.16	0.05	0.12	7.95	0.40	0.10	95.43	5fb 9 1
856	37.76	1.65	14.13	0.23	18.37	0.11	14.43	0.60	0.15	0.10	0.17	8.79	0.36	0.05	96.75	5fb 9 2
857	36.16	1.80	13.79	0.92	19.16	0.10	14.19	0.59	0.13	0.07	0.18	7.44	0.31	0.06	94.75	5fb 10 1
858	37.04	1.76	14.16	1.05	18.28	0.10	13.71	0.70	0.18	0.08	0.24	8.10	0.34	0.07	95.65	5fb10 2

Table Aya Phlogopite. (continued).

No.	SiO2	TiO2	Al2O3	Cr2O3	FeO	MnO	MgO	BaO	CaO	NiO	Na2O	K2O	F	Cl	Total	Comment
859	37.72	1.67	14.53	0.66	18.32	0.10	13.81	0.71	0.11	0.06	0.33	8.60	0.39	0.07	96.90	5fb10 3
860	30.63	1.49	15.10	0.69	19.13	0.39	19.17	0.12	0.20	0.02	0.11	1.40	0.28	0.05	88.66	5fb 11 1 alt
861	29.56	1.43	15.19	0.82	19.49	0.41	20.07	0.04	0.11	0.05	0.05	0.34	0.28	0.04	87.74	5fb 11 2 alt
862	37.29	1.78	13.82	0.05	18.23	0.10	14.03	0.57	0.06	0.09	0.03	9.27	0.49	0.06	95.64	5fb 12 1
863	37.65	1.74	14.32	0.11	18.56	0.11	13.92	0.58	0.10	0.08	0.11	9.36	0.41	0.04	96.92	5fb 12 2
864	38.01	1.80	14.43	0.09	18.46	0.10	14.60	0.67	0.05	0.07	0.12	8.82	0.47	0.06	97.52	5fb 13 1
865	37.97	1.75	14.23	0.00	18.34	0.09	14.20	0.66	0.11	0.08	0.15	8.60	0.46	0.05	96.47	5fb 13 2
866	37.96	1.73	14.28	0.04	18.11	0.07	14.27	0.77	0.03	0.11	0.08	9.21	0.46	0.05	96.96	5fb 14 1
867	37.92	1.59	13.88	0.09	18.42	0.06	13.88	0.62	0.01	0.05	0.07	9.30	0.44	0.07	96.19	5fb 14 2
868	37.51	1.65	14.28	0.07	18.74	0.09	14.07	0.67	0.03	0.11	0.14	8.92	0.42	0.06	96.55	5fb 15 1
869	37.42	1.62	13.90	0.11	18.98	0.09	14.41	0.56	0.04	0.11	0.19	8.32	0.43	0.05	96.04	5fb 15 2

Table Aya Phlogopite. Structural formula based on 11 oxygens.

No.	Si	Ti	Al	Cr	Fe	Mn	Mg	Ba	Ca	Ni	Na	K	F	Cl	Total	Comment
4	2.829	0.105	1.250	0.085	0.682	0.004	1.991	0.021	0.000	0.005	0.022	0.829	0.141	0.000	7.964	5iBc 1-1
5	2.860	0.110	1.225	0.075	0.669	0.005	1.971	0.021	0.000	0.005	0.027	0.851	0.154	0.001	7.975	5iBc 1-2
6	2.826	0.110	1.265	0.083	0.655	0.004	1.970	0.024	0.000	0.005	0.028	0.865	0.143	0.000	7.980	5iBc 1-3
7	2.859	0.093	1.234	0.022	0.681	0.004	2.054	0.029	0.006	0.004	0.016	0.854	0.165	0.000	8.021	5iBr 1-1
8	2.864	0.085	1.239	0.004	0.657	0.004	2.108	0.032	0.007	0.005	0.021	0.831	0.185	0.004	8.045	5iBr 1-2
9	2.850	0.098	1.262	0.047	0.653	0.004	2.018	0.031	0.001	0.005	0.032	0.823	0.155	0.000	7.980	5iBr 1-3
10	2.844	0.113	1.259	0.059	0.679	0.002	1.980	0.015	0.002	0.005	0.022	0.831	0.150	0.000	7.961	5iBc 2-1
11	2.843	0.104	1.260	0.054	0.678	0.003	1.981	0.018	0.002	0.006	0.027	0.869	0.152	0.000	7.996	5iBc 2-2
12	2.846	0.111	1.225	0.107	0.661	0.002	1.964	0.016	0.001	0.006	0.027	0.853	0.147	0.000	7.965	5iBc 2-3
13	2.797	0.094	1.205	0.033	0.739	0.008	2.259	0.009	0.002	0.004	0.038	0.640	0.152	0.000	7.981	5iBr 2-1
14	2.843	0.094	1.223	0.038	0.687	0.005	2.113	0.014	0.001	0.006	0.028	0.791	0.146	0.001	7.990	5iBr 2-2
15	2.882	0.088	1.249	0.011	0.656	0.004	2.033	0.024	0.003	0.005	0.012	0.884	0.185	0.000	8.034	5iBr 2-3
16	2.857	0.112	1.218	0.086	0.664	0.003	1.975	0.021	0.000	0.008	0.035	0.838	0.136	0.009	7.961	5iBc 3-1
17	2.845	0.110	1.249	0.048	0.665	0.002	1.999	0.021	0.000	0.008	0.033	0.868	0.161	0.001	8.009	5iBc 3-2
18	2.896	0.092	1.206	0.019	0.644	0.003	2.056	0.027	0.001	0.005	0.011	0.891	0.187	0.000	8.038	5iBc 3-3
19	2.942	0.080	1.197	0.005	0.640	0.003	2.038	0.021	0.005	0.006	0.013	0.868	0.157	0.001	7.975	5iBr 3-1
20	2.869	0.112	1.211	0.062	0.667	0.003	1.985	0.028	0.001	0.006	0.026	0.851	0.153	0.002	7.975	5iBr 3-2
21	2.875	0.084	1.230	0.009	0.674	0.003	2.070	0.031	0.003	0.004	0.024	0.856	0.193	0.001	8.056	5iBr 3-3
22	2.876	0.084	1.279	0.001	0.650	0.002	2.036	0.022	0.000	0.008	0.026	0.859	0.169	0.000	8.012	5iB circle 2 c 4-1
23	2.878	0.084	1.277	0.004	0.645	0.003	2.041	0.023	0.002	0.006	0.020	0.848	0.175	0.000	8.006	5iB circle 2 c 4-2
24	2.888	0.084	1.253	0.003	0.639	0.004	2.058	0.023	0.001	0.005	0.026	0.861	0.183	0.000	8.027	5iB circle 2 c 4-3
25	2.872	0.086	1.259	0.003	0.643	0.003	2.066	0.027	0.003	0.006	0.027	0.862	0.179	0.002	8.036	5iB circle 2 r 4-1
26	2.898	0.088	1.219	0.004	0.634	0.003	2.085	0.022	0.000	0.005	0.016	0.874	0.204	0.000	8.052	5iB circle 2 r 4-2
27	2.893	0.089	1.283	0.004	0.667	0.006	1.936	0.026	0.005	0.008	0.009	0.908	0.185	0.001	8.018	5iB circle 2 r 4-3
28	2.898	0.092	1.206	0.019	0.652	0.003	2.066	0.038	0.001	0.007	0.029	0.802	0.176	0.000	7.989	5iB circle 2 c 5-1
29	2.932	0.083	1.183	0.016	0.639	0.002	2.093	0.022	0.001	0.006	0.029	0.792	0.175	0.000	7.972	5iB circle 2 c 5-2
30	2.871	0.086	1.280	0.023	0.645	0.003	2.024	0.027	0.004	0.007	0.029	0.811	0.144	0.000	7.955	5iB circle 2 c 5-3
31	2.853	0.092	1.302	0.048	0.653	0.004	1.974	0.030	0.005	0.006	0.029	0.799	0.143	0.001	7.938	5iB circle 2 r 5-1
32	2.863	0.088	1.280	0.022	0.662	0.004	2.024	0.024	0.005	0.006	0.023	0.815	0.158	0.001	7.976	5iB circle 2 r 5-2
33	2.893	0.086	1.202	0.010	0.663	0.007	2.148	0.021	0.017	0.006	0.028	0.700	0.149	0.003	7.931	5iB circle 2 r 5-3
34	2.880	0.127	1.196	0.021	0.579	0.003	2.111	0.020	0.000	0.008	0.030	0.846	0.171	0.002	7.996	5iA circle 1 c 1-1
35	2.877	0.083	1.213	0.025	0.596	0.003	2.151	0.025	0.000	0.006	0.031	0.855	0.171	0.002	8.038	5iA circle 1 c 1-2
36	2.840	0.126	1.205	0.095	0.599	0.006	2.038	0.021	0.001	0.006	0.034	0.859	0.154	0.003	7.986	5iA circle 1 c 1-3
37	2.907	0.081	1.203	0.002	0.595	0.004	2.137	0.033	0.001	0.008	0.027	0.855	0.185	0.003	8.038	5iA circle 1 r 1-1
38	2.888	0.079	1.229	0.002	0.597	0.003	2.140	0.021	0.000	0.006	0.032	0.875	0.154	0.002	8.027	5iA circle 1 r 1-2
39	2.866	0.113	1.193	0.039	0.612	0.004	2.108	0.023	0.002	0.005	0.024	0.852	0.170	0.003	8.016	5iA circle 1 r 1-3
40	2.895	0.084	1.200	0.005	0.585	0.005	2.167	0.028	0.000	0.009	0.025	0.860	0.177	0.005	8.044	5iA circle 1 c 2-1
41	2.895	0.086	1.195	0.052	0.585	0.003	2.115	0.022	0.000	0.006	0.025	0.851	0.168	0.004	8.006	5iA circle 1 c 2-2

Table Aya Phlogopite. (continued).

No.	Si	Ti	Al	Cr	Fe	Mn	Mg	Ba	Ca	Ni	Na	K	F	Cl	Total	Comment
42	2.878	0.081	1.214	0.028	0.607	0.005	2.142	0.020	0.001	0.005	0.024	0.858	0.165	0.004	8.030	5iA circle 1 c 2-3
43	2.931	0.074	1.149	0.008	0.580	0.005	2.182	0.022	0.004	0.008	0.011	0.894	0.202	0.002	8.073	5iA circle 1 r 2-1
44	2.856	0.123	1.197	0.087	0.607	0.005	2.045	0.021	0.001	0.006	0.021	0.843	0.149	0.002	7.962	5iA circle 1 r 2-2
45	2.846	0.089	1.228	0.074	0.602	0.003	2.104	0.020	0.000	0.009	0.017	0.862	0.150	0.004	8.008	5iA circle 1 r 2-3
46	2.890	0.087	1.208	0.052	0.593	0.004	2.096	0.020	0.000	0.006	0.031	0.845	0.153	0.002	7.987	5iA circle 2 c 1-1
47	2.871	0.098	1.191	0.032	0.616	0.003	2.137	0.019	0.002	0.008	0.017	0.870	0.178	0.001	8.043	5iA circle 2 c 1-2
48	2.892	0.103	1.167	0.046	0.589	0.003	2.126	0.019	0.000	0.010	0.021	0.868	0.166	0.003	8.011	5iA circle 2 c 1-3
49	2.902	0.068	1.190	0.009	0.596	0.006	2.198	0.018	0.001	0.006	0.016	0.856	0.175	0.005	8.046	5iA circle 2 r 1-1
50	2.871	0.072	1.209	0.009	0.610	0.006	2.211	0.026	0.004	0.007	0.012	0.837	0.191	0.003	8.068	5iA circle 2 r 1-2
51	2.890	0.087	1.197	0.053	0.609	0.003	2.087	0.022	0.001	0.008	0.024	0.858	0.158	0.004	8.001	5iA circle 2 r 1-3
52	2.881	0.082	1.235	0.011	0.642	0.004	2.070	0.020	0.008	0.008	0.028	0.880	0.154	0.003	8.025	5iA circle 2 c 2-1
53	2.891	0.086	1.205	0.049	0.619	0.003	2.071	0.019	0.005	0.005	0.031	0.855	0.132	0.004	7.976	5iA circle 2 c 2-2
54	2.896	0.085	1.222	0.041	0.607	0.004	2.080	0.020	0.007	0.007	0.017	0.820	0.162	0.001	7.970	5iA circle 2 c 2-3
55	2.879	0.077	1.207	0.010	0.628	0.005	2.146	0.029	0.005	0.006	0.011	0.879	0.190	0.004	8.074	5iA circle 2 r 2-1
56	2.898	0.078	1.200	0.000	0.610	0.006	2.172	0.019	0.013	0.006	0.013	0.830	0.208	0.005	8.057	5iA circle 2 r 2-2
57	2.817	0.073	1.248	0.024	0.643	0.005	2.228	0.016	0.018	0.007	0.021	0.767	0.162	0.002	8.031	5iA circle 2 r 2-3
58	2.877	0.090	1.220	0.047	0.571	0.005	2.111	0.021	0.008	0.007	0.028	0.853	0.156	0.002	7.997	5iA circle 3 r 1-1
59	2.895	0.075	1.211	0.018	0.598	0.004	2.124	0.026	0.008	0.009	0.013	0.883	0.182	0.002	8.048	5iA circle 3 r 1-2
60	2.920	0.080	1.259	0.004	0.565	0.006	2.076	0.022	0.006	0.006	0.010	0.844	0.195	0.001	7.992	5iA circle 3 r 1-3
61	2.854	0.101	1.231	0.086	0.579	0.003	2.057	0.026	0.002	0.006	0.028	0.856	0.142	0.002	7.972	5iA circle 3 c 1-1
62	2.860	0.094	1.229	0.074	0.605	0.005	2.060	0.022	0.002	0.006	0.031	0.844	0.144	0.003	7.978	5iA circle 3 c 1-2
63	2.867	0.091	1.221	0.049	0.603	0.005	2.116	0.019	0.004	0.007	0.027	0.826	0.152	0.005	7.991	5iA circle 3 c 1-3
64	2.844	0.093	1.236	0.084	0.601	0.006	2.066	0.023	0.002	0.006	0.021	0.864	0.153	0.002	8.001	5iA circle 3 c 2-1
65	2.860	0.105	1.217	0.056	0.617	0.006	2.065	0.016	0.004	0.006	0.014	0.883	0.163	0.003	8.013	5iA circle 3 c 2-2
66	2.875	0.085	1.247	0.058	0.592	0.004	2.070	0.019	0.002	0.008	0.022	0.837	0.159	0.002	7.978	5iA circle 3 c 2-3
67	2.867	0.085	1.235	0.042	0.602	0.006	2.115	0.021	0.003	0.006	0.025	0.835	0.165	0.002	8.007	5iA circle 3 r 2-1
68	2.909	0.083	1.192	0.033	0.571	0.005	2.134	0.019	0.002	0.006	0.028	0.860	0.175	0.001	8.017	5iA circle 3 r 2-2
69	2.853	0.083	1.253	0.047	0.695	0.004	2.038	0.018	0.008	0.007	0.027	0.787	0.164	0.001	7.986	5iA circle 3 r 2-3
70	2.848	0.084	1.260	0.043	0.587	0.005	2.109	0.021	0.002	0.005	0.028	0.875	0.163	0.001	8.031	5iA circle 4 r 1-1
71	2.913	0.080	1.184	0.000	0.570	0.004	2.189	0.019	0.009	0.006	0.028	0.856	0.177	0.001	8.035	5iA circle 4 r 1-2
72	2.866	0.067	1.248	0.010	0.606	0.006	2.176	0.019	0.002	0.007	0.017	0.843	0.172	0.002	8.040	5iA circle 4 r 1-3
73	2.850	0.111	1.232	0.072	0.606	0.005	2.047	0.019	0.001	0.007	0.030	0.846	0.145	0.003	7.972	5iA circle 4 c 1-1
74	2.898	0.083	1.226	0.021	0.616	0.002	2.084	0.025	0.001	0.008	0.027	0.839	0.157	0.001	7.987	5iA circle 4 c 1-2
75	2.895	0.086	1.209	0.058	0.585	0.004	2.079	0.019	0.000	0.005	0.027	0.860	0.142	0.002	7.972	5iA circle 4 c 1-3
76	2.891	0.081	1.193	0.042	0.630	0.003	2.107	0.019	0.003	0.007	0.026	0.845	0.158	0.003	8.007	5iA circle 4 c 2-1
77	2.863	0.095	1.205	0.080	0.593	0.003	2.081	0.020	0.002	0.004	0.036	0.870	0.140	0.001	7.993	5iA circle 4 c 2-2
78	2.869	0.105	1.203	0.068	0.599	0.004	2.072	0.019	0.007	0.007	0.027	0.847	0.147	0.001	7.975	5iA circle 4 c 2-3
79	2.897	0.084	1.174	0.038	0.605	0.002	2.130	0.019	0.006	0.006	0.025	0.880	0.160	0.002	8.027	5iA circle 4 r 2-1

Table Ayn Phlogopite (continued).

No.	Si	Ti	Al	Cr	Fe	Mn	Mg	Ba	Ca	Ni	Na	K	F	Cl	Total	Comment
80	2.913	0.078	1.213	0.002	0.584	0.002	2.146	0.017	0.010	0.008	0.029	0.832	0.178	0.002	8.013	SiA circle 4 r 2-2
81	2.918	0.081	1.172	0.020	0.586	0.004	2.160	0.023	0.004	0.009	0.027	0.830	0.171	0.002	8.006	SiA circle 4 r 2-3
82	2.862	0.099	1.206	0.090	0.624	0.003	2.030	0.019	0.008	0.006	0.027	0.862	0.137	0.002	7.975	SiA circle 5 r 1-1
83	2.871	0.143	1.200	0.047	0.592	0.003	2.047	0.017	0.004	0.006	0.026	0.839	0.146	0.003	7.943	SiA circle 5 r 1-2
84	2.863	0.092	1.263	0.095	0.593	0.004	2.007	0.019	0.003	0.009	0.029	0.808	0.130	0.000	7.914	SiA circle 5 r 1-3
85	2.878	0.094	1.236	0.085	0.592	0.004	2.030	0.020	0.000	0.004	0.028	0.826	0.133	0.001	7.929	SiA circle 5 c 1-1
86	2.865	0.103	1.204	0.085	0.621	0.003	2.031	0.020	0.000	0.006	0.030	0.871	0.139	0.000	7.978	SiA circle 5 c 1-2
87	2.894	0.103	1.177	0.036	0.625	0.004	2.081	0.029	0.000	0.007	0.019	0.863	0.172	0.003	8.012	SiA circle 5 c 1-3
88	2.891	0.090	1.183	0.056	0.608	0.002	2.109	0.018	0.001	0.006	0.025	0.849	0.139	0.002	7.978	SiA circle 5 c 2-1
89	2.908	0.091	1.188	0.018	0.628	0.002	2.085	0.026	0.001	0.006	0.019	0.873	0.173	0.003	8.021	SiA circle 5 c 2-2
90	2.884	0.095	1.200	0.031	0.640	0.003	2.079	0.021	0.001	0.008	0.029	0.859	0.163	0.000	8.012	SiA circle 5 c 2-3
91	2.876	0.095	1.218	0.060	0.614	0.005	2.064	0.017	0.009	0.006	0.026	0.833	0.136	0.000	7.957	SiA circle 5 r 2-1
92	2.879	0.098	1.193	0.063	0.610	0.003	2.102	0.022	0.001	0.006	0.023	0.818	0.142	0.001	7.958	SiA circle 5 r 2-2
93	2.898	0.092	1.207	0.021	0.598	0.004	2.106	0.021	0.002	0.008	0.030	0.844	0.146	0.000	7.978	SiA circle 5 r 2-3
94	2.875	0.078	1.240	0.035	0.608	0.002	2.125	0.029	0.000	0.008	0.014	0.804	0.164	0.003	7.985	SiA circle 6 r 1-1
95	2.916	0.082	1.182	0.035	0.562	0.004	2.149	0.023	0.004	0.006	0.012	0.848	0.185	0.003	8.010	SiA circle 6 r 1-2
96	2.916	0.069	1.177	0.015	0.584	0.003	2.184	0.025	0.002	0.007	0.014	0.864	0.196	0.002	8.057	SiA circle 6 r 1-3
97	2.910	0.080	1.196	0.005	0.577	0.003	2.177	0.029	0.001	0.007	0.026	0.825	0.173	0.001	8.010	SiA circle 6 c 1-1
98	2.855	0.085	1.237	0.061	0.595	0.003	2.105	0.022	0.001	0.008	0.028	0.850	0.143	0.001	7.994	SiA circle 6 c 1-2
99	2.852	0.094	1.236	0.074	0.600	0.004	2.070	0.022	0.001	0.008	0.027	0.851	0.139	0.003	7.981	SiA circle 6 c 1-3
100	2.928	0.080	1.181	0.000	0.582	0.002	2.168	0.020	0.000	0.009	0.027	0.836	0.172	0.002	8.007	SiA circle 6 c 2-1
101	2.907	0.113	1.176	0.002	0.577	0.003	2.150	0.020	0.003	0.006	0.026	0.847	0.181	0.002	8.011	SiA circle 6 c 2-2
102	2.910	0.076	1.203	0.001	0.582	0.003	2.175	0.025	0.000	0.010	0.023	0.830	0.179	0.000	8.018	SiA circle 6 c 2-3
103	2.874	0.068	1.206	0.017	0.588	0.004	2.240	0.019	0.002	0.008	0.012	0.827	0.178	0.000	8.043	SiA circle 6 r 2-1
104	2.892	0.071	1.203	0.012	0.590	0.003	2.203	0.024	0.000	0.007	0.007	0.842	0.208	0.000	8.062	SiA circle 6 r 2-2
105	2.903	0.064	1.199	0.014	0.556	0.005	2.241	0.021	0.007	0.008	0.003	0.817	0.212	0.000	8.049	SiA circle 6 r 2-3
106	2.824	0.123	1.252	0.061	0.865	0.006	1.786	0.022	0.004	0.003	0.027	0.877	0.102	0.003	7.953	Sj circle 1 r 1-1
107	2.846	0.109	1.255	0.038	0.843	0.003	1.837	0.019	0.001	0.001	0.032	0.864	0.115	0.002	7.963	Sj circle 1 r 1-2
108	2.853	0.109	1.246	0.030	0.814	0.005	1.847	0.027	0.005	0.001	0.009	0.918	0.119	0.001	7.985	Sj circle 1 r 1-3
109	2.832	0.121	1.237	0.048	0.838	0.006	1.883	0.017	0.002	0.005	0.026	0.807	0.104	0.002	7.927	Sj circle 1 c 1-1
110	2.836	0.125	1.253	0.044	0.872	0.005	1.780	0.025	0.000	0.003	0.037	0.857	0.106	0.002	7.945	Sj circle 1 c 1-2
111	2.833	0.124	1.245	0.041	0.869	0.004	1.814	0.023	0.002	0.004	0.028	0.857	0.107	0.003	7.953	Sj circle 1 c 1-3
112	2.853	0.102	1.251	0.035	0.842	0.003	1.849	0.023	0.000	0.003	0.029	0.852	0.119	0.002	7.964	Sj circle 1 c 2-1
113	2.829	0.106	1.267	0.038	0.855	0.005	1.838	0.022	0.001	0.003	0.026	0.872	0.108	0.005	7.975	Sj circle 1 c 2-2
114	2.860	0.102	1.250	0.027	0.877	0.005	1.863	0.027	0.002	0.003	0.010	0.761	0.138	0.002	7.925	Sj circle 1 c 2-3
115	2.857	0.103	1.259	0.023	0.829	0.005	1.879	0.021	0.001	0.000	0.019	0.821	0.121	0.003	7.943	Sj circle 1 r 2-1
116	2.844	0.102	1.262	0.012	0.851	0.005	1.901	0.023	0.000	0.000	0.012	0.820	0.111	0.001	7.945	Sj circle 1 r 2-2
117	2.870	0.103	1.251	0.020	0.833	0.004	1.872	0.025	0.000	0.000	0.015	0.815	0.144	0.005	7.955	Sj circle 1 r 2-3

Table A5a Phlogopite. (continued).

No.	Si	Ti	Al	Cr	Fe	Mn	Mg	Ba	Ca	Ni	Na	K	F	Cl	Total	Comment
118	2.876	0.100	1.234	0.003	0.793	0.005	1.961	0.023	0.001	0.001	0.017	0.803	0.151	0.003	7.970	Sj circle 2 r 1-1
119	2.890	0.096	1.244	0.002	0.775	0.005	1.950	0.017	0.004	0.001	0.014	0.801	0.120	0.004	7.922	Sj circle 2 r 1-2
120	2.876	0.104	1.245	0.006	0.792	0.005	1.924	0.030	0.004	0.003	0.020	0.796	0.136	0.002	7.941	Sj circle 2 r 1-3
121	2.855	0.112	1.260	0.032	0.812	0.005	1.870	0.018	0.000	0.003	0.031	0.809	0.099	0.002	7.908	Sj circle 2 c 1-1
122	2.868	0.107	1.242	0.025	0.800	0.006	1.897	0.019	0.001	0.002	0.030	0.819	0.086	0.001	7.903	Sj circle 2 c 1-2
123	2.902	0.096	1.202	0.001	0.787	0.004	1.964	0.016	0.001	0.001	0.017	0.836	0.124	0.003	7.954	Sj circle 2 c 1-3
124	2.864	0.116	1.241	0.041	0.859	0.005	1.829	0.022	0.001	0.003	0.029	0.771	0.094	0.001	7.875	Sj circle 2 c 2-1
125	2.866	0.124	1.218	0.052	0.800	0.005	1.883	0.019	0.001	0.003	0.032	0.779	0.103	0.001	7.885	Sj circle 2 c 2-2
126	2.877	0.116	1.233	0.004	0.812	0.005	1.906	0.028	0.004	0.002	0.032	0.768	0.111	0.004	7.903	Sj circle 2 c 2-3
127	2.864	0.125	1.220	0.043	0.806	0.005	1.876	0.020	0.000	0.001	0.030	0.807	0.106	0.005	7.909	Sj circle 2 r 2-1
128	2.898	0.113	1.215	0.005	0.814	0.005	1.882	0.022	0.001	0.004	0.020	0.824	0.142	0.002	7.945	Sj circle 2 r 2-2
129	2.905	0.094	1.210	0.002	0.790	0.006	1.954	0.016	0.001	0.003	0.022	0.809	0.124	0.001	7.936	Sj circle 2 r 2-3
130	2.865	0.105	1.263	0.027	0.843	0.004	1.840	0.019	0.007	0.001	0.026	0.794	0.099	0.003	7.897	Sj circle 3 r 1-1
131	2.866	0.106	1.255	0.021	0.842	0.005	1.859	0.025	0.002	0.000	0.022	0.801	0.107	0.006	7.916	Sj circle 3 r 1-2
132	2.856	0.091	1.271	0.009	0.856	0.005	1.882	0.023	0.007	0.000	0.007	0.819	0.127	0.002	7.955	Sj circle 3 r 1-3
133	2.864	0.124	1.229	0.036	0.871	0.007	1.820	0.025	0.002	0.001	0.021	0.786	0.106	0.002	7.891	Sj circle 3 c 1-1
134	2.852	0.126	1.230	0.034	0.867	0.006	1.818	0.021	0.001	0.000	0.019	0.847	0.120	0.003	7.946	Sj circle 3 c 1-2
135	2.846	0.125	1.220	0.038	0.872	0.005	1.831	0.023	0.001	0.001	0.035	0.843	0.111	0.004	7.953	Sj circle 3 c 1-3
136	2.840	0.123	1.238	0.035	0.846	0.004	1.845	0.024	0.000	0.003	0.028	0.858	0.117	0.002	7.963	Sj circle 3 c 2-1
137	2.839	0.129	1.224	0.050	0.883	0.007	1.779	0.025	0.002	0.001	0.010	0.904	0.148	0.004	8.005	Sj circle 3 c 2-2
138	2.833	0.116	1.265	0.045	0.837	0.005	1.819	0.021	0.002	0.000	0.036	0.873	0.110	0.002	7.962	Sj circle 3 c 2-3
139	2.832	0.097	1.274	0.035	0.847	0.005	1.849	0.023	0.004	0.002	0.013	0.883	0.130	0.003	7.997	Sj circle 3 r 2-1
140	2.819	0.109	1.269	0.047	0.833	0.005	1.863	0.024	0.005	0.003	0.031	0.842	0.119	0.003	7.972	Sj circle 3 r 2-2
141	2.878	0.095	1.303	0.011	0.858	0.006	1.774	0.025	0.008	0.000	0.018	0.807	0.130	0.005	7.918	Sj circle 3 r 2-3
142	2.846	0.105	1.235	0.007	0.817	0.004	1.922	0.030	0.002	0.001	0.024	0.895	0.145	0.004	8.037	Sj circle 4 r 1-1
143	2.876	0.100	1.206	0.009	0.789	0.003	1.960	0.020	0.007	0.003	0.017	0.871	0.153	0.005	8.019	Sj circle 4 r 1-2
144	2.838	0.104	1.264	0.051	0.818	0.003	1.853	0.020	0.001	0.003	0.031	0.863	0.112	0.005	7.965	Sj circle 4 r 1-3
145	2.849	0.105	1.241	0.078	0.797	0.003	1.848	0.019	0.000	0.005	0.027	0.855	0.116	0.002	7.946	Sj circle 4 c 1-1
146	2.850	0.103	1.254	0.037	0.810	0.004	1.876	0.021	0.000	0.006	0.032	0.851	0.123	0.000	7.966	Sj circle 4 c 1-2
147	2.828	0.104	1.273	0.044	0.810	0.005	1.874	0.019	0.001	0.005	0.034	0.861	0.128	0.002	7.987	Sj circle 4 c 1-3
148	2.841	0.111	1.254	0.037	0.823	0.003	1.850	0.025	0.000	0.003	0.022	0.889	0.125	0.002	7.984	Sj circle 4 c 2-1
149	2.852	0.107	1.233	0.037	0.814	0.004	1.886	0.022	0.000	0.003	0.033	0.866	0.123	0.002	7.981	Sj circle 4 c 2-2
150	2.840	0.107	1.227	0.037	0.842	0.007	1.898	0.020	0.001	0.004	0.026	0.855	0.120	0.003	7.985	Sj circle 4 c 2-3
151	2.842	0.114	1.241	0.006	0.848	0.005	1.895	0.023	0.001	0.003	0.023	0.860	0.134	0.002	7.998	Sj circle 4 r 2-1
152	2.862	0.103	1.239	0.006	0.803	0.005	1.909	0.024	0.004	0.003	0.013	0.898	0.138	0.003	8.008	Sj circle 4 r 2-2
153	2.837	0.108	1.252	0.051	0.791	0.004	1.898	0.017	0.011	0.002	0.036	0.826	0.120	0.001	7.955	Sj circle 4 r 2-3
418	2.864	0.106	1.215	0.096	0.634	0.006	2.000	0.023	0.002	0.007	0.025	0.815	0.120	0.002	7.916	SiA l c 1
419	2.870	0.104	1.211	0.089	0.646	0.004	1.985	0.017	0.004	0.006	0.032	0.848	0.122	0.002	7.940	SiA l c 2

Table A5a Phlogopite. (continued).

No.	Si	Ti	Al	Cr	Fe	Mn	Mg	Ba	Ca	Ni	Na	K	F	Cl	Total	Comment
420	2.867	0.105	1.217	0.095	0.609	0.005	2.001	0.022	0.002	0.006	0.033	0.856	0.131	0.000	7.948	SiA 1 c 3
421	2.867	0.084	1.247	0.055	0.635	0.004	2.036	0.021	0.005	0.005	0.027	0.853	0.137	0.001	7.976	SiA 1 r 1
422	2.868	0.100	1.216	0.089	0.626	0.003	2.012	0.022	0.004	0.006	0.028	0.843	0.131	0.001	7.948	SiA 1 r 2
423	2.910	0.080	1.200	0.000	0.661	0.005	2.079	0.021	0.002	0.017	0.031	0.834	0.161	0.002	8.004	SiA 1 r 3
424	2.905	0.087	1.214	0.034	0.632	0.004	2.036	0.025	0.006	0.006	0.026	0.853	0.144	0.001	7.970	SiA 2 r 1
425	2.873	0.092	1.235	0.045	0.633	0.004	2.038	0.022	0.004	0.005	0.029	0.864	0.141	0.001	7.984	SiA 2 r 2
426	2.880	0.095	1.217	0.064	0.612	0.004	2.052	0.021	0.003	0.003	0.031	0.842	0.143	0.003	7.966	SiA 2 r 3
428	2.935	0.088	1.187	0.022	0.621	0.005	2.039	0.027	0.002	0.006	0.019	0.861	0.159	0.000	7.971	SiA 2 c 2
429	2.908	0.081	1.210	0.018	0.648	0.004	2.061	0.030	0.003	0.005	0.027	0.834	0.164	0.000	7.992	SiA 2 c 3
430	2.887	0.105	1.190	0.059	0.620	0.004	2.050	0.018	0.001	0.008	0.032	0.852	0.140	0.000	7.965	SiA 3 c 1
431	2.891	0.094	1.190	0.030	0.633	0.003	2.082	0.024	0.001	0.007	0.031	0.869	0.146	0.001	8.002	SiA 3 c 2
432	2.862	0.133	1.195	0.081	0.604	0.004	2.014	0.020	0.000	0.008	0.035	0.859	0.137	0.000	7.951	SiA 3 c 3
433	2.877	0.106	1.213	0.079	0.613	0.004	2.001	0.019	0.002	0.006	0.030	0.873	0.130	0.002	7.955	SiA 3 r 1
434	2.910	0.081	1.197	0.007	0.626	0.004	2.088	0.030	0.000	0.008	0.022	0.892	0.173	0.000	8.037	SiA 3 r 2
435	2.911	0.082	1.209	0.000	0.623	0.005	2.092	0.019	0.003	0.006	0.030	0.876	0.159	0.004	8.018	SiA 3 r 3
436	2.871	0.096	1.191	0.061	0.637	0.006	2.077	0.018	0.007	0.006	0.023	0.851	0.153	0.000	7.997	SiA 4 r 1 kinked
437	2.870	0.114	1.180	0.070	0.628	0.006	2.066	0.018	0.012	0.006	0.025	0.817	0.141	0.001	7.954	SiA 4 r 2 kinked
438	2.882	0.109	1.191	0.085	0.637	0.006	1.998	0.017	0.010	0.006	0.029	0.830	0.150	0.001	7.951	SiA 4 r 3 kinked
439	2.901	0.097	1.182	0.074	0.624	0.005	2.030	0.020	0.006	0.006	0.029	0.832	0.150	0.000	7.954	SiA 4 c 1 kinked
440	2.861	0.100	1.225	0.088	0.650	0.006	1.988	0.019	0.008	0.009	0.027	0.833	0.141	0.000	7.954	SiA 4 c 2 kinked
441	2.897	0.090	1.217	0.049	0.625	0.004	2.027	0.021	0.003	0.005	0.027	0.863	0.152	0.000	7.978	SiA 4 c 3 kinked
442	2.883	0.116	1.209	0.066	0.617	0.005	1.986	0.020	0.002	0.005	0.026	0.881	0.151	0.001	7.968	SiA 5 c 1 kinked
443	2.880	0.089	1.229	0.055	0.672	0.005	1.994	0.018	0.008	0.006	0.029	0.842	0.150	0.003	7.979	SiA 5 c 2 kinked
444	2.914	0.090	1.219	0.052	0.612	0.004	2.009	0.018	0.002	0.006	0.030	0.840	0.159	0.003	7.958	SiA 5 c 3 kinked
445	2.899	0.080	1.225	0.036	0.718	0.005	1.975	0.017	0.012	0.005	0.026	0.811	0.146	0.003	7.957	SiA 5 r 1 kinked
446	2.910	0.103	1.180	0.045	0.625	0.005	2.015	0.018	0.015	0.007	0.028	0.877	0.165	0.000	7.993	SiA 5 r 2 kinked
447	2.923	0.086	1.204	0.040	0.603	0.005	2.039	0.021	0.003	0.006	0.021	0.857	0.155	0.000	7.963	SiA 5 r 3 kinked
448	2.896	0.087	1.207	0.083	0.613	0.005	2.003	0.022	0.002	0.007	0.025	0.870	0.140	0.000	7.959	SiA 6 r 1
449	2.965	0.073	1.188	0.001	0.584	0.005	2.100	0.004	0.002	0.005	0.023	0.866	0.165	0.000	7.978	SiA 6 r 2
450	2.876	0.100	1.224	0.081	0.630	0.005	1.984	0.023	0.002	0.007	0.030	0.855	0.141	0.002	7.958	SiA 6 r 3
6c	2.933	0.087	1.181	0.011	0.621	0.005	2.072	0.026	0.000	0.006	0.021	0.860	0.183	0.000	8.007	SiA 6 c 3
453	2.878	0.102	1.204	0.088	0.640	0.006	1.989	0.027	0.003	0.005	0.032	0.835	0.147	0.000	7.955	SiA 7 c 1
454	2.893	0.093	1.186	0.075	0.618	0.005	2.034	0.024	0.004	0.007	0.026	0.864	0.156	0.001	7.985	SiA 7 c 2
455	2.889	0.099	1.219	0.062	0.629	0.003	1.996	0.032	0.002	0.007	0.030	0.839	0.162	0.002	7.970	SiA 7 c 3
456	2.892	0.099	1.217	0.053	0.644	0.007	1.991	0.022	0.008	0.005	0.029	0.846	0.146	0.000	7.958	SiA 7 r 1
457	2.898	0.100	1.205	0.072	0.628	0.006	1.996	0.018	0.007	0.006	0.029	0.825	0.143	0.000	7.933	SiA 7 r 2
458	2.880	0.131	1.190	0.066	0.625	0.006	2.000	0.017	0.009	0.007	0.025	0.835	0.151	0.001	7.943	SiA 7 r 3
462	2.927	0.070	1.186	0.001	0.593	0.005	2.174	0.003	0.006	0.009	0.031	0.840	0.144	0.003	7.992	SiA 8 c 1z

Table A.ys Phlogopite. (continued).

No.	Si	Ti	Al	Cr	Fe	Mn	Mg	Ba	Ca	Ni	Na	K	F	Cl	Total	Comment
463	2.944	0.071	1.180	0.001	0.592	0.005	2.160	0.004	0.007	0.009	0.028	0.814	0.152	0.003	7.969	5iA 8 c 2z
464	2.896	0.063	1.179	0.003	0.572	0.008	2.347	0.006	0.007	0.007	0.027	0.698	0.148	0.004	7.964	5iA 8 c 3z
465	2.506	0.057	1.409	0.003	0.825	0.024	2.846	0.000	0.013	0.007	0.010	0.075	0.115	0.001	7.891	5iA 9 c 1z
466	2.933	0.069	1.175	0.002	0.594	0.005	2.177	0.003	0.005	0.008	0.025	0.848	0.109	0.003	7.957	5iA 9 c 2z
467	2.840	0.059	1.208	0.000	0.594	0.010	2.483	0.003	0.009	0.006	0.020	0.554	0.152	0.003	7.939	5iA 9 c 3z
468	2.898	0.060	1.183	0.003	0.620	0.008	2.278	0.003	0.011	0.007	0.029	0.732	0.150	0.004	7.985	5iA 9 r 1z
469	2.897	0.057	1.157	0.002	0.594	0.007	2.355	0.008	0.009	0.009	0.023	0.722	0.151	0.003	7.992	5iA 9 r 2z
470	2.957	0.067	1.188	0.004	0.562	0.005	2.127	0.020	0.007	0.008	0.009	0.861	0.186	0.004	8.004	5iA 9 r 3z
471	2.825	0.164	1.181	0.107	0.615	0.006	2.012	0.018	0.012	0.009	0.031	0.807	0.132	0.006	7.925	5iA 10r 1
472	2.874	0.087	1.238	0.072	0.618	0.005	2.006	0.024	0.006	0.011	0.031	0.856	0.137	0.002	7.966	5iA 10 r 2
473	2.870	0.089	1.202	0.104	0.626	0.007	2.015	0.021	0.010	0.010	0.017	0.848	0.135	0.005	7.960	5iA 10 r 3
474	2.877	0.091	1.205	0.095	0.611	0.007	2.033	0.016	0.006	0.009	0.030	0.839	0.138	0.002	7.957	5iA 10 c 1
475	2.844	0.097	1.220	0.118	0.626	0.005	1.998	0.022	0.008	0.011	0.029	0.853	0.130	0.004	7.965	5iA 10 c 2
476	2.866	0.127	1.202	0.064	0.608	0.006	2.034	0.022	0.005	0.009	0.029	0.836	0.139	0.003	7.948	5iA 10 c 3
477	2.876	0.095	1.195	0.080	0.607	0.007	2.053	0.020	0.017	0.009	0.031	0.832	0.127	0.004	7.953	5iA 11 kinked
478	2.881	0.095	1.199	0.077	0.592	0.005	2.075	0.020	0.015	0.009	0.035	0.799	0.157	0.005	7.965	5iA 11 kinked
479	2.848	0.096	1.253	0.091	0.634	0.004	1.993	0.019	0.000	0.010	0.027	0.849	0.124	0.002	7.948	5iA 12 c 1
480	2.875	0.100	1.216	0.074	0.613	0.003	2.020	0.023	0.002	0.006	0.029	0.871	0.137	0.000	7.968	5iA 12 c 2
481	2.884	0.092	1.218	0.069	0.604	0.004	2.037	0.021	0.002	0.008	0.030	0.856	0.148	0.003	7.973	5iA 12 c 3
482	2.879	0.094	1.211	0.080	0.625	0.003	2.019	0.020	0.002	0.008	0.030	0.853	0.141	0.000	7.964	5iA 12 r 1
483	2.872	0.091	1.236	0.080	0.622	0.003	2.020	0.022	0.002	0.008	0.028	0.821	0.134	0.003	7.941	5iA 12 r 2
484	2.892	0.083	1.206	0.023	0.610	0.003	2.118	0.030	0.003	0.008	0.030	0.845	0.182	0.003	8.033	5iA 12 r 3
485	2.875	0.075	1.181	0.000	0.672	0.004	2.252	0.015	0.004	0.009	0.022	0.724	0.150	0.002	7.985	5ib 1 r 1
486	2.868	0.087	1.220	0.005	0.697	0.004	2.062	0.031	0.001	0.007	0.027	0.871	0.176	0.003	8.061	5ib 1 r 2
487	2.838	0.105	1.250	0.056	0.676	0.003	1.997	0.019	0.001	0.006	0.037	0.869	0.139	0.002	7.998	5ib 1 r 3
488	2.816	0.104	1.275	0.045	0.667	0.002	2.020	0.020	0.000	0.007	0.035	0.891	0.129	0.000	8.012	5ib 1 c 1
489	2.854	0.102	1.238	0.037	0.656	0.004	2.030	0.026	0.002	0.007	0.031	0.869	0.156	0.002	8.014	5ib 1 c 2
490	2.870	0.099	1.237	0.031	0.663	0.004	2.015	0.021	0.000	0.008	0.032	0.872	0.134	0.001	7.984	5ib 1 c 3
491	2.833	0.103	1.259	0.074	0.664	0.004	1.975	0.019	0.002	0.006	0.036	0.883	0.128	0.001	7.986	5ib 2 c 1
492	2.863	0.097	1.208	0.043	0.690	0.006	2.024	0.029	0.003	0.006	0.013	0.883	0.174	0.004	8.041	5ib 2 c 2
493	2.834	0.105	1.231	0.085	0.674	0.002	1.992	0.017	0.004	0.006	0.030	0.874	0.118	0.001	7.973	5ib 2 c 3
494	2.808	0.109	1.251	0.095	0.681	0.003	1.978	0.018	0.008	0.007	0.033	0.874	0.122	0.002	7.989	5ib 2 r 1
495	2.909	0.078	1.195	0.009	0.627	0.004	2.127	0.030	0.004	0.008	0.029	0.805	0.165	0.004	7.996	5ib 2 r 2
496	2.820	0.099	1.268	0.073	0.665	0.004	1.986	0.016	0.007	0.007	0.032	0.901	0.114	0.002	7.992	5ib 2 r 3
497	2.862	0.107	1.192	0.087	0.661	0.002	2.009	0.018	0.002	0.006	0.031	0.861	0.158	0.000	7.996	5ib 3 r 1
498	2.844	0.104	1.209	0.099	0.667	0.003	1.987	0.022	0.003	0.007	0.033	0.873	0.135	0.001	7.987	5ib 3 r 2
499	2.823	0.104	1.246	0.110	0.678	0.004	1.969	0.024	0.003	0.005	0.024	0.831	0.130	0.000	7.952	5ib 3 r 3
500	2.785	0.114	1.264	0.117	0.687	0.005	1.954	0.020	0.000	0.005	0.035	0.884	0.128	0.000	7.998	5ib 3 c 1

Table Aya Phlogopite. (continued).

No.	Si	Ti	Al	Cr	Fe	Mn	Mg	Ba	Ca	Ni	Na	K	F	Cl	Total	Comment
501	2.817	0.116	1.242	0.112	0.673	0.004	1.941	0.020	0.002	0.006	0.031	0.887	0.138	0.001	7.989	5ib 3 c 2
502	2.784	0.110	1.272	0.107	0.679	0.004	1.980	0.019	0.002	0.006	0.032	0.874	0.140	0.000	8.009	5ib 3 c 3
503	2.875	0.067	1.194	0.015	0.637	0.004	2.239	0.008	0.004	0.003	0.023	0.794	0.163	0.001	8.027	5ib 4 c 1
504	2.872	0.074	1.197	0.013	0.648	0.006	2.211	0.013	0.005	0.003	0.024	0.794	0.194	0.002	8.055	5ib 4 c 2
505	2.864	0.083	1.231	0.023	0.645	0.004	2.075	0.027	0.008	0.006	0.009	0.912	0.200	0.002	8.089	5ib 4 r 1
506	2.777	0.073	1.269	0.015	0.700	0.010	2.287	0.018	0.009	0.004	0.019	0.670	0.159	0.004	8.016	5ib 4 r 2
507	2.851	0.103	1.243	0.062	0.649	0.006	2.001	0.019	0.005	0.006	0.028	0.869	0.142	0.000	7.983	5ib 5 r 1
508	2.858	0.097	1.239	0.032	0.698	0.006	2.004	0.031	0.003	0.006	0.022	0.852	0.152	0.002	8.000	5ib 5 r 2
509	2.872	0.096	1.245	0.017	0.655	0.003	2.043	0.021	0.006	0.004	0.026	0.850	0.148	0.002	7.989	5ib 5 r 3
510	2.865	0.103	1.240	0.041	0.657	0.005	2.000	0.019	0.002	0.004	0.030	0.879	0.144	0.000	7.989	5ib 5 c 1
511	2.842	0.101	1.269	0.047	0.674	0.004	1.979	0.019	0.002	0.004	0.032	0.886	0.141	0.002	8.002	5ib 5 c 2
512	2.841	0.101	1.267	0.059	0.669	0.004	1.976	0.021	0.002	0.005	0.028	0.876	0.124	0.000	7.970	5ib 5 c 3
513	2.785	0.099	1.291	0.061	0.686	0.006	2.020	0.022	0.001	0.006	0.025	0.898	0.144	0.001	8.046	5ib6 c 1
514	2.774	0.104	1.304	0.111	0.661	0.005	1.975	0.015	0.000	0.007	0.028	0.888	0.113	0.000	7.985	5ib 6 c 2
515	2.796	0.104	1.298	0.091	0.645	0.005	1.976	0.020	0.000	0.007	0.036	0.893	0.118	0.000	7.988	5ib 6 c 3
516	2.773	0.105	1.290	0.100	0.689	0.005	1.974	0.019	0.004	0.005	0.031	0.897	0.119	0.000	8.011	5ib 6 r 1
517	2.806	0.100	1.287	0.090	0.648	0.003	1.991	0.018	0.002	0.005	0.027	0.881	0.125	0.003	7.987	5ib 6 r 2
518	2.884	0.079	1.225	0.017	0.629	0.005	2.116	0.026	0.002	0.004	0.015	0.846	0.191	0.000	8.039	5ib 6 r 3
725	2.859	0.114	1.295	0.000	0.925	0.006	1.739	0.027	0.001	0.000	0.026	0.805	0.106	0.003	7.905	5d 1 c 1
726	2.825	0.113	1.313	0.000	0.911	0.005	1.767	0.034	0.003	0.002	0.028	0.833	0.103	0.001	7.941	5d 1 c 2
727	2.853	0.109	1.277	0.000	0.883	0.005	1.807	0.025	0.005	0.002	0.022	0.848	0.135	0.004	7.974	5d 1 c 3
728	2.852	0.124	1.280	0.000	0.911	0.005	1.752	0.028	0.003	0.002	0.025	0.829	0.109	0.006	7.926	5d 1 r 1
729	2.861	0.109	1.289	0.000	0.898	0.004	1.759	0.031	0.006	0.000	0.027	0.825	0.105	0.005	7.920	5d 1 r 2
730	2.865	0.113	1.277	0.000	0.887	0.004	1.781	0.025	0.005	0.000	0.029	0.822	0.115	0.003	7.926	5d 1 r 3
731	2.847	0.109	1.295	0.000	0.915	0.006	1.750	0.031	0.009	0.001	0.022	0.849	0.108	0.003	7.944	5d 2 r 1
732	2.838	0.100	1.327	0.000	0.920	0.005	1.730	0.029	0.008	0.003	0.020	0.862	0.111	0.004	7.954	5d 2 r 2
733	2.853	0.099	1.285	0.000	0.905	0.005	1.789	0.024	0.015	0.001	0.015	0.843	0.113	0.004	7.951	5d 2 r 3
734	2.830	0.115	1.303	0.000	0.918	0.005	1.769	0.030	0.001	0.001	0.020	0.847	0.121	0.004	7.963	5d 2 c1
735	2.841	0.115	1.283	0.000	0.920	0.005	1.770	0.030	0.001	0.004	0.011	0.858	0.127	0.004	7.969	5d 2 c2
736	2.831	0.114	1.313	0.000	0.916	0.005	1.774	0.031	0.002	0.000	0.025	0.798	0.113	0.002	7.925	5d 2 c3
737	2.847	0.117	1.303	0.000	0.918	0.005	1.727	0.032	0.009	0.001	0.034	0.816	0.121	0.008	7.939	5d 3 c1
738	2.821	0.111	1.307	0.000	0.931	0.006	1.774	0.032	0.014	0.002	0.017	0.822	0.133	0.005	7.973	5d 3 c2
739	2.865	0.111	1.278	0.000	0.903	0.005	1.778	0.026	0.006	0.002	0.026	0.799	0.109	0.003	7.910	5d 3 c3
740	2.889	0.106	1.250	0.000	0.898	0.004	1.780	0.025	0.011	0.000	0.015	0.821	0.124	0.004	7.927	5d 3 r1
741	2.844	0.109	1.313	0.000	0.903	0.005	1.758	0.030	0.011	0.002	0.028	0.801	0.118	0.006	7.929	5d 3 r2
742	2.885	0.091	1.246	0.000	0.884	0.005	1.816	0.021	0.016	0.001	0.016	0.854	0.143	0.007	7.985	5d 3 r3
743	2.842	0.105	1.277	0.000	0.903	0.004	1.805	0.024	0.013	0.000	0.010	0.870	0.153	0.005	8.012	5d 4 r1
744	2.856	0.102	1.265	0.000	0.890	0.005	1.792	0.023	0.029	0.000	0.021	0.878	0.133	0.005	7.998	5d 4 r2

Table Aya Phlogopite. (continued).

No.	Si	Ti	Al	Cr	Fe	Mn	Mg	Ba	Ca	Ni	Na	K	F	Cl	Total	Comment
745	2.903	0.105	1.316	0.000	0.876	0.003	1.688	0.030	0.010	0.001	0.026	0.780	0.093	0.007	7.838	5d 4 r3
746	2.904	0.114	1.272	0.000	0.877	0.004	1.715	0.026	0.001	0.001	0.031	0.837	0.096	0.007	7.883	5d 4 c1
747	2.887	0.114	1.298	0.000	0.891	0.002	1.691	0.029	0.009	0.001	0.028	0.826	0.107	0.007	7.890	5d 4 c2
748	2.877	0.115	1.315	0.000	0.879	0.002	1.709	0.031	0.007	0.000	0.036	0.799	0.106	0.006	7.881	5d 4 c3
749	2.895	0.120	1.339	0.000	0.896	0.003	1.699	0.034	0.009	0.002	0.024	0.618	0.110	0.003	7.750	5d 5 c1
750	2.901	0.114	1.247	0.000	0.898	0.003	1.766	0.031	0.002	0.002	0.028	0.770	0.097	0.003	7.859	5d 5 c2
751	2.886	0.120	1.226	0.000	0.919	0.003	1.779	0.032	0.001	0.000	0.024	0.805	0.110	0.005	7.909	5d 5 c3
752	2.894	0.116	1.227	0.000	0.890	0.004	1.798	0.029	0.001	0.000	0.028	0.807	0.102	0.004	7.900	5d 5 c4
753	2.868	0.121	1.239	0.001	0.921	0.004	1.792	0.033	0.004	0.001	0.028	0.785	0.099	0.006	7.902	5d 5 r1
754	2.874	0.101	1.246	0.000	0.929	0.004	1.799	0.025	0.004	0.003	0.015	0.816	0.125	0.003	7.945	5d 5 r2
755	2.868	0.117	1.240	0.000	0.932	0.002	1.785	0.036	0.005	0.001	0.026	0.790	0.107	0.003	7.913	5d 5 r3
756	2.875	0.105	1.238	0.000	0.929	0.004	1.797	0.039	0.001	0.002	0.027	0.796	0.117	0.006	7.935	5d 6 r1
757	2.930	0.079	1.203	0.000	0.863	0.003	1.866	0.019	0.006	0.000	0.011	0.833	0.152	0.005	7.968	5d 6 r2
758	2.901	0.105	1.209	0.000	0.900	0.004	1.813	0.023	0.007	0.000	0.015	0.836	0.131	0.003	7.948	5d 6 r3
759	2.868	0.119	1.248	0.002	0.932	0.004	1.771	0.036	0.003	0.001	0.031	0.780	0.107	0.003	7.904	5d 6 c1
760	2.873	0.118	1.241	0.001	0.953	0.003	1.752	0.032	0.004	0.002	0.023	0.795	0.119	0.006	7.922	5d 6 c2
761	2.863	0.113	1.242	0.001	0.953	0.003	1.763	0.034	0.003	0.003	0.019	0.834	0.125	0.003	7.957	5d 6 c3
762	2.885	0.106	1.247	0.000	0.913	0.004	1.789	0.030	0.002	0.001	0.029	0.790	0.109	0.006	7.910	5d 7 c1
763	2.883	0.111	1.236	0.000	0.918	0.004	1.791	0.030	0.000	0.001	0.026	0.804	0.113	0.006	7.922	5d 7 c2
764	2.906	0.108	1.229	0.000	0.909	0.004	1.777	0.027	0.005	0.000	0.030	0.784	0.115	0.006	7.900	5d 7 c3
765	2.878	0.111	1.251	0.000	0.938	0.003	1.762	0.032	0.003	0.000	0.032	0.785	0.103	0.005	7.902	5d 7 r1
766	2.928	0.093	1.202	0.000	0.918	0.004	1.804	0.022	0.004	0.001	0.027	0.786	0.108	0.005	7.899	5d 7 r2
767	2.929	0.105	1.186	0.000	0.904	0.003	1.804	0.025	0.003	0.001	0.025	0.801	0.120	0.002	7.908	5d 7 r3
768	2.895	0.100	1.222	0.001	0.878	0.004	1.832	0.022	0.003	0.001	0.019	0.854	0.132	0.003	7.966	5d 8 1
769	2.941	0.093	1.167	0.000	0.880	0.004	1.871	0.017	0.002	0.000	0.012	0.806	0.137	0.003	7.932	5d 8 2
770	2.950	0.094	1.210	0.000	0.877	0.004	1.820	0.018	0.005	0.002	0.013	0.732	0.141	0.004	7.868	5d 8 3
771	2.861	0.092	1.243	0.000	0.919	0.005	1.850	0.020	0.001	0.002	0.014	0.853	0.145	0.005	8.009	5d 9 1
772	2.901	0.085	1.244	0.003	0.862	0.005	1.840	0.021	0.008	0.001	0.021	0.821	0.123	0.007	7.941	5d 10 1
773	2.867	0.093	1.276	0.002	0.874	0.005	1.791	0.032	0.018	0.001	0.070	0.818	0.112	0.015	7.973	5d 10 2
774	2.871	0.115	1.261	0.046	0.868	0.002	1.761	0.023	0.000	0.003	0.037	0.783	0.115	0.007	7.892	5d 10 c1
775	2.831	0.118	1.283	0.078	0.907	0.005	1.704	0.024	0.002	0.003	0.031	0.805	0.104	0.008	7.901	5d 10 c2
776	2.857	0.119	1.253	0.056	0.889	0.003	1.750	0.024	0.001	0.002	0.033	0.800	0.105	0.007	7.898	5d 10 c3
777	2.868	0.109	1.254	0.029	0.886	0.004	1.807	0.020	0.002	0.002	0.027	0.775	0.104	0.004	7.891	5d 10 r1
778	2.862	0.118	1.271	0.048	0.886	0.004	1.742	0.022	0.001	0.001	0.034	0.781	0.104	0.005	7.877	5d 10 r2
779	2.847	0.116	1.261	0.084	0.889	0.005	1.729	0.023	0.006	0.000	0.037	0.777	0.115	0.005	7.893	5d 10 r3
780	2.850	0.101	1.278	0.045	0.885	0.003	1.784	0.024	0.008	0.003	0.027	0.789	0.117	0.006	7.919	5d 11 r1
781	2.828	0.108	1.303	0.040	0.910	0.004	1.746	0.028	0.010	0.000	0.035	0.794	0.113	0.008	7.929	5d 11 r2
782	2.840	0.103	1.295	0.027	0.901	0.004	1.780	0.024	0.008	0.002	0.031	0.797	0.116	0.004	7.932	5d 11 r3

Table Aya Phlogopite. (continued).

No.	Si	Ti	Al	Cr	Fe	Mn	Mg	Ba	Ca	Ni	Na	K	F	Cl	Total	Comment
783	2.412	0.080	1.531	0.003	0.933	0.024	2.726	0.000	0.016	0.000	0.015	0.023	0.096	0.010	7.866	5d 11 r4 alt
784	2.837	0.105	1.302	0.066	0.870	0.003	1.753	0.021	0.004	0.001	0.032	0.795	0.115	0.005	7.908	5d 11 c1
785	2.836	0.108	1.301	0.053	0.906	0.002	1.730	0.023	0.004	0.005	0.035	0.788	0.097	0.006	7.893	5d 11 c2
786	2.851	0.113	1.274	0.031	0.912	0.005	1.748	0.030	0.002	0.003	0.024	0.806	0.120	0.010	7.928	5d 11 c3
787	2.879	0.106	1.265	0.000	0.891	0.004	1.796	0.024	0.002	0.004	0.034	0.788	0.128	0.005	7.926	5d 12 c1
788	2.843	0.099	1.298	0.001	0.922	0.004	1.800	0.022	0.002	0.004	0.028	0.800	0.099	0.009	7.932	5d 12 c2
789	2.902	0.098	1.249	0.004	0.884	0.003	1.795	0.021	0.001	0.002	0.036	0.793	0.116	0.007	7.911	5d 12 c3
790	4.233	0.000	1.300	0.000	0.011	0.002	0.000	0.001	0.000	0.002	0.002	1.135	0.000	0.001	6.687	5d 12 c4 alt
791	4.177	0.001	1.312	0.000	0.013	0.001	0.000	0.000	0.001	0.004	0.007	1.307	0.000	0.000	6.823	5d 12 c5 alt
792	2.887	0.101	1.232	0.006	0.852	0.007	1.859	0.021	0.008	0.006	0.022	0.810	0.166	0.005	7.980	5d 12 r1
793	2.875	0.101	1.248	0.006	0.841	0.007	1.862	0.021	0.012	0.007	0.036	0.798	0.167	0.007	7.988	5d 12 r2
794	2.868	0.099	1.277	0.010	0.899	0.007	1.773	0.021	0.008	0.008	0.032	0.809	0.155	0.009	7.974	5d 13 1
795	2.856	0.101	1.311	0.006	0.907	0.006	1.743	0.022	0.008	0.005	0.032	0.810	0.153	0.007	7.965	5d 13 2
796	2.814	0.109	1.304	0.008	0.936	0.008	1.788	0.023	0.010	0.005	0.030	0.801	0.160	0.005	8.001	5d 13 3
797	2.895	0.101	1.254	0.014	0.867	0.005	1.800	0.029	0.005	0.006	0.031	0.762	0.148	0.008	7.923	5d 14 1
798	2.868	0.103	1.278	0.012	0.876	0.009	1.779	0.030	0.002	0.006	0.023	0.825	0.155	0.006	7.970	5d 14 2
799	2.845	0.112	1.284	0.037	0.874	0.008	1.740	0.025	0.001	0.007	0.029	0.869	0.148	0.002	7.982	5d 15 c1
800	2.851	0.120	1.268	0.064	0.899	0.005	1.703	0.021	0.004	0.006	0.026	0.820	0.127	0.003	7.916	5d 15 c2
801	2.845	0.117	1.282	0.044	0.873	0.007	1.736	0.024	0.003	0.006	0.022	0.855	0.145	0.005	7.963	5d 15 c3
802	2.870	0.100	1.264	0.008	0.867	0.006	1.783	0.026	0.005	0.007	0.005	0.909	0.195	0.006	8.051	5d 15 r1
803	2.881	0.106	1.251	0.016	0.875	0.008	1.767	0.022	0.011	0.008	0.018	0.852	0.174	0.005	7.995	5d 15 r2
804	2.868	0.101	1.269	0.010	0.873	0.010	1.785	0.025	0.011	0.005	0.021	0.851	0.151	0.004	7.982	5d 15 r3
805	2.855	0.098	1.293	0.033	0.870	0.007	1.767	0.025	0.003	0.006	0.031	0.824	0.148	0.008	7.968	5d 16 1
806	2.839	0.103	1.249	0.026	0.902	0.007	1.789	0.025	0.006	0.009	0.024	0.907	0.175	0.021	8.081	5d 16 2
807	2.871	0.102	1.262	0.005	0.870	0.007	1.812	0.033	0.012	0.007	0.024	0.807	0.144	0.004	7.958	5d 17 1
808	2.873	0.095	1.268	0.004	0.869	0.007	1.809	0.024	0.007	0.007	0.021	0.846	0.161	0.005	7.995	5d 17 2
809	2.899	0.094	1.226	0.009	0.855	0.007	1.854	0.027	0.003	0.008	0.024	0.791	0.163	0.005	7.966	5d 18 1
810	2.957	0.094	1.228	0.000	0.878	0.005	1.766	0.028	0.007	0.000	0.021	0.723	0.136	0.003	7.845	5d 18 2
811	2.906	0.107	1.267	0.000	0.900	0.005	1.710	0.027	0.001	0.001	0.022	0.838	0.108	0.002	7.892	5d 19 1
812	2.907	0.107	1.284	0.000	0.875	0.005	1.741	0.028	0.000	0.002	0.027	0.765	0.129	0.003	7.872	5d 19 2
813	2.891	0.106	1.289	0.000	0.891	0.005	1.733	0.033	0.001	0.001	0.026	0.793	0.124	0.006	7.898	5d 19 3
814	2.888	0.104	1.293	0.000	0.927	0.005	1.688	0.031	0.004	0.002	0.039	0.800	0.123	0.006	7.910	5d 20 1
815	2.923	0.103	1.260	0.000	0.894	0.003	1.720	0.024	0.004	0.002	0.037	0.782	0.121	0.007	7.882	5d 20 2
816	2.839	0.105	1.295	0.070	1.006	0.005	1.612	0.025	0.008	0.004	0.031	0.781	0.096	0.003	7.879	5d 21 1
817	2.859	0.113	1.274	0.060	0.955	0.006	1.644	0.025	0.002	0.001	0.028	0.819	0.114	0.005	7.903	5d 21 2
818	2.857	0.100	1.300	0.039	0.902	0.005	1.713	0.024	0.004	0.000	0.032	0.823	0.118	0.006	7.924	5d 21 3
819	2.925	0.098	1.254	0.000	0.907	0.006	1.703	0.027	0.005	0.003	0.018	0.822	0.123	0.005	7.897	5d 22 1
820	2.896	0.111	1.268	0.000	0.918	0.005	1.688	0.036	0.004	0.002	0.029	0.828	0.112	0.003	7.902	5d 22 2

Table Aya Phlogopite. (continued).

No.	Si	Ti	Al	Cr	Fe	Mn	Mg	Ba	Ca	Ni	Na	K	F	Cl	Total	Comment
821	0.005	0.001	0.000	0.000	0.093	0.038	0.015	0.000	10.834	0.000	0.000	0.016	0.000	0.000	11.002	5d 23 1 alt
822	0.004	0.002	0.000	0.000	0.049	0.044	0.103	0.000	10.781	0.000	0.001	0.024	0.000	0.003	11.010	5d 23 2 alt
823	0.000	0.001	0.001	0.000	0.140	0.096	0.076	0.000	10.672	0.002	0.006	0.013	0.000	0.003	11.010	5d 23 3 alt
824	2.878	0.114	1.276	0.000	0.902	0.005	1.751	0.027	0.001	0.000	0.024	0.808	0.124	0.002	7.912	5d 24 1
825	2.907	0.097	1.252	0.000	0.890	0.006	1.771	0.030	0.009	0.002	0.031	0.785	0.122	0.004	7.904	5d 24 2
826	2.880	0.102	1.271	0.000	0.901	0.007	1.761	0.034	0.003	0.001	0.021	0.829	0.133	0.002	7.942	5d 24 3
827	2.873	0.105	1.295	0.000	0.907	0.004	1.732	0.026	0.004	0.004	0.020	0.832	0.131	0.004	7.936	5d 25 1
828	2.883	0.100	1.254	0.000	0.951	0.004	1.751	0.024	0.004	0.000	0.010	0.829	0.156	0.005	7.971	5d 25 2
829	2.898	0.107	1.265	0.000	0.931	0.004	1.707	0.024	0.002	0.002	0.028	0.816	0.133	0.004	7.922	5d 26 1
830	2.900	0.105	1.269	0.000	0.901	0.003	1.743	0.027	0.004	0.000	0.026	0.792	0.110	0.006	7.886	5d 26 2
831	2.438	0.081	1.589	0.030	1.023	0.038	2.444	0.000	0.014	0.000	0.012	0.015	0.066	0.004	7.754	5fb 1 1 alt
832	2.459	0.080	1.548	0.036	1.090	0.035	2.380	0.000	0.015	0.000	0.014	0.036	0.074	0.006	7.775	5fb 1 2 alt
833	2.396	0.085	1.608	0.026	1.040	0.041	2.477	0.000	0.013	0.000	0.010	0.022	0.067	0.004	7.790	5fb 1 3 alt
834	2.419	0.081	1.592	0.056	1.061	0.039	2.396	0.000	0.017	0.000	0.013	0.020	0.071	0.004	7.768	5fb 2 1 alt
835	2.435	0.093	1.540	0.073	1.047	0.036	2.389	0.001	0.011	0.000	0.012	0.074	0.065	0.006	7.780	5fb 2 2 alt
836	2.445	0.088	1.512	0.050	1.151	0.032	2.345	0.000	0.014	0.000	0.011	0.087	0.074	0.003	7.813	5fb 2 3 alt
837	2.423	0.079	1.391	0.015	1.603	0.014	2.224	0.001	0.021	0.000	0.009	0.037	0.083	0.007	7.907	5fb 3 1 alt
838	2.436	0.091	1.462	0.042	1.194	0.033	2.417	0.001	0.018	0.000	0.013	0.044	0.076	0.007	7.832	5fb 3 2 alt
839	2.423	0.075	1.580	0.025	1.078	0.042	2.433	0.000	0.020	0.000	0.016	0.034	0.095	0.004	7.824	5fb 4 1 alt
840	2.439	0.080	1.555	0.035	1.103	0.035	2.404	0.000	0.020	0.000	0.013	0.021	0.075	0.007	7.785	5fb 4 2 alt
841	2.844	0.105	1.264	0.045	1.169	0.004	1.511	0.021	0.007	0.000	0.023	0.834	0.073	0.008	7.906	5fb 5 c1
842	2.838	0.104	1.271	0.047	1.143	0.003	1.541	0.018	0.014	0.000	0.033	0.808	0.083	0.008	7.910	5fb 5 c2
843	2.852	0.096	1.258	0.038	1.132	0.001	1.581	0.021	0.009	0.001	0.028	0.806	0.095	0.006	7.922	5fb 5 c3
844	2.835	0.097	1.245	0.005	1.183	0.007	1.592	0.021	0.019	0.000	0.016	0.865	0.122	0.010	8.015	5fb 5 r1
845	2.875	0.096	1.258	0.005	1.108	0.004	1.566	0.018	0.013	0.002	0.026	0.878	0.130	0.008	7.987	5fb 5 r2
846	2.848	0.104	1.274	0.027	1.153	0.005	1.522	0.022	0.008	0.001	0.027	0.838	0.096	0.006	7.931	5fb 5 r3
847	2.878	0.104	1.223	0.001	1.163	0.005	1.560	0.019	0.006	0.002	0.009	0.888	0.107	0.010	7.972	5fb 6 1
848	2.807	0.104	1.240	0.003	1.213	0.005	1.659	0.019	0.003	0.003	0.006	0.817	0.112	0.009	8.000	5fb 6 2
849	2.422	0.084	1.575	0.045	1.175	0.043	2.306	0.000	0.023	0.000	0.018	0.008	0.069	0.008	7.774	5fb 7 1 alt
850	2.412	0.090	1.572	0.055	1.179	0.041	2.301	0.001	0.016	0.000	0.015	0.021	0.057	0.005	7.765	5fb 7 2 alt
851	2.442	0.075	1.578	0.013	1.140	0.043	2.350	0.000	0.030	0.003	0.019	0.009	0.064	0.014	7.780	5fb 8 c1 alt
852	2.401	0.073	1.641	0.004	1.221	0.063	2.257	0.001	0.023	0.003	0.028	0.010	0.087	0.019	7.830	5fb 8 c2 alt
853	2.805	0.090	1.283	0.012	1.205	0.007	1.576	0.020	0.016	0.006	0.030	0.847	0.088	0.009	7.993	5fb 8 r1 alt
854	2.774	0.096	1.255	0.015	1.230	0.007	1.702	0.014	0.017	0.007	0.028	0.729	0.090	0.009	7.973	5fb 8 r2 alt
855	2.826	0.100	1.237	0.010	1.198	0.006	1.647	0.015	0.013	0.003	0.017	0.771	0.096	0.012	7.953	5fb 9 1
856	2.836	0.093	1.251	0.014	1.154	0.007	1.616	0.018	0.012	0.006	0.024	0.842	0.085	0.007	7.964	5fb 9 2
857	2.780	0.104	1.250	0.056	1.232	0.006	1.625	0.018	0.011	0.004	0.027	0.730	0.076	0.008	7.926	5fb 10 1
858	2.815	0.100	1.268	0.063	1.162	0.007	1.554	0.021	0.015	0.005	0.036	0.785	0.081	0.009	7.919	5fb10 2

Table Aya Phlogopite. (continued).

No.	Si	Ti	Al	Cr	Fe	Mn	Mg	Ba	Ca	Ni	Na	K	F	Cl	Total	Comment
859	2.829	0.094	1.284	0.039	1.149	0.006	1.544	0.021	0.008	0.004	0.048	0.823	0.092	0.009	7.951	5fb10 3
860	2.456	0.090	1.427	0.044	1.283	0.026	2.291	0.004	0.017	0.001	0.017	0.144	0.072	0.007	7.878	5fb 11 1 alt
861	2.389	0.087	1.447	0.053	1.317	0.028	2.418	0.001	0.010	0.003	0.008	0.035	0.071	0.006	7.872	5fb 11 2 alt
862	2.843	0.102	1.242	0.003	1.162	0.006	1.594	0.017	0.005	0.006	0.005	0.902	0.118	0.007	8.011	5fb 12 1
863	2.833	0.098	1.270	0.006	1.168	0.007	1.561	0.017	0.008	0.005	0.015	0.898	0.099	0.005	7.992	5fb 12 2
864	2.830	0.101	1.267	0.005	1.149	0.006	1.620	0.020	0.004	0.004	0.018	0.837	0.111	0.007	7.979	5fb 13 1
865	2.853	0.099	1.261	0.000	1.153	0.006	1.590	0.019	0.009	0.005	0.022	0.825	0.108	0.007	7.955	5fb 13 2
866	2.847	0.098	1.263	0.002	1.136	0.005	1.595	0.023	0.002	0.007	0.011	0.881	0.108	0.007	7.984	5fb 14 1
867	2.871	0.091	1.239	0.005	1.166	0.004	1.566	0.018	0.001	0.003	0.010	0.898	0.106	0.009	7.985	5fb 14 2
868	2.831	0.094	1.270	0.004	1.183	0.006	1.583	0.020	0.002	0.007	0.021	0.859	0.100	0.007	7.985	5fb 15 1
869	2.834	0.092	1.241	0.007	1.202	0.006	1.627	0.017	0.003	0.007	0.028	0.804	0.103	0.007	7.976	5fb 15 2

Table Spinel. Peter and K-L spinel compositions (wt. %).

No.	MgO	Al2O3	Cr2O3	MnO	FeO	Nb2O5	TiO2	Total	Comment
3	11.27	6.58	0.11	0.55	59.44	0.02	17.86	95.84	2a 1c
4	10.99	7.10	0.19	0.49	58.89	0.00	17.39	95.05	2a 2 c
5	11.49	6.69	0.09	0.56	59.59	0.00	17.89	96.31	2a 3 c
6	10.56	5.63	2.06	0.50	59.05	0.00	17.85	95.65	2a 4 c
7	11.40	8.14	0.21	0.50	58.53	0.02	16.97	95.75	2a 5 c
8	11.41	7.83	0.24	0.58	58.17	0.00	16.54	94.77	2a 6 c
9	12.06	8.10	0.10	0.54	58.36	0.00	16.64	95.81	2a 7 c
10	11.60	9.23	0.00	0.53	57.82	0.00	16.01	95.19	2a 8 c
11	12.23	9.57	0.02	0.56	57.23	0.00	15.10	94.71	2a-2a 9 c
12	11.77	8.36	0.13	0.53	58.69	0.00	16.49	95.96	2a-2a 10 c
13	11.79	7.75	0.11	0.58	58.17	0.00	16.95	95.35	2a-2a 11 c
14	12.77	9.73	0.00	0.62	57.58	0.01	15.19	95.90	2a-2a 12 c
15	11.24	8.73	0.03	0.50	58.74	0.00	16.44	95.67	2a-2a 13 c
16	12.40	10.02	0.00	0.58	57.08	0.00	15.21	95.29	2a-2a 14 c
17	11.31	6.71	0.10	0.54	59.10	0.01	17.81	95.58	2a-2a 15 c
18	11.25	6.55	0.45	0.57	58.61	0.08	17.65	95.16	2a-2a 16 c
19	12.68	9.95	0.00	0.67	57.37	0.00	15.01	95.68	2a-2a 17 c
20	10.84	6.21	0.46	0.56	59.50	0.00	18.15	95.71	2a-2a 18 c
21	10.82	6.70	0.06	0.50	59.81	0.04	17.87	95.79	2a-2a 19 c
22	12.27	10.02	0.00	0.58	56.86	0.02	14.85	94.60	2a-2a 20 c
23	13.73	10.77	0.01	0.63	56.39	0.06	14.87	96.44	2a-2a 21 c
24	15.86	10.27	0.00	0.96	55.13	0.09	8.58	90.88	2a-2a 21 a
25	11.79	9.78	0.02	0.53	56.73	0.00	15.73	94.57	2a-2a 22 c
26	13.17	11.12	0.02	0.66	56.20	0.00	14.38	95.56	2a-2a 23 c
27	11.29	6.43	0.06	0.48	59.76	0.00	18.06	96.09	2a-2a 24 c
28	12.42	9.75	0.00	0.52	57.63	0.03	15.71	96.05	2a-2a 25 c
29	11.65	8.41	0.13	0.53	57.83	0.05	16.41	95.00	2a-2a 26 c
30	11.57	6.86	0.21	0.62	58.81	0.00	17.61	95.68	2a-2a 27 c
31	10.00	8.78	38.69	0.41	32.89	0.00	5.02	95.77	2a-2a 29 c
32	13.06	10.30	0.01	0.64	56.72	0.00	14.81	95.54	2a-2a 30 c
33	11.81	7.78	0.12	0.57	57.61	0.05	16.58	94.53	2a-2a 31 c
34	11.85	8.78	0.05	0.56	58.10	0.00	16.69	96.04	2a-2a 32 c
35	11.97	8.84	0.01	0.56	58.30	0.00	16.29	95.98	2a-2a 33 c
36	12.51	10.42	0.02	0.58	56.89	0.01	15.25	95.67	2a-2a 34 c
37	11.50	6.80	0.29	0.54	59.48	0.00	17.76	96.36	2a-2a 35 c
38	11.94	9.06	0.04	0.52	58.28	0.03	16.13	95.99	2a-2a 36 c
39	12.17	7.82	0.23	0.58	58.25	0.01	16.63	95.68	2a-2a 37 c
40	13.53	11.19	0.07	0.71	56.31	0.05	14.15	95.99	2a-2a 38 c
41	11.20	6.35	0.36	0.59	58.29	0.04	17.54	94.37	2a-2a 39 c
42	12.00	9.34	0.03	0.55	58.20	0.02	16.13	96.28	2a-2a 40 c
43	12.73	11.10	0.00	0.53	56.96	0.00	14.90	96.22	2a-2a 41 c
44	11.99	6.84	0.10	0.54	60.25	0.00	17.78	97.51	2a-2a 42 c
45	11.51	7.02	0.15	0.58	59.28	0.00	17.39	95.93	2a-2a 43 c
46	12.22	9.12	0.03	0.61	58.46	0.00	15.64	96.07	2a-2a 44 c
47	11.76	8.18	0.15	0.53	59.40	0.00	16.72	96.73	2a-2a 45 c
48	10.93	5.64	1.81	0.56	59.29	0.02	17.55	95.79	2a-2a 46 c
49	12.50	9.89	0.09	0.58	57.54	0.00	15.32	95.91	2a-2a 47 c
50	12.87	9.95	0.03	0.59	57.62	0.00	14.90	95.95	2a-2a 48 c
51	11.59	6.27	0.12	0.58	60.26	0.00	17.77	96.58	2a-2a 49 c
52	11.85	6.47	1.70	0.63	58.83	0.00	17.14	96.62	2a-2a 50 c
53	12.60	8.86	0.17	0.63	57.88	0.00	16.23	96.37	2a-2a 51 c
54	12.43	9.71	0.02	0.61	57.78	0.00	15.00	95.55	2a-2a 52 c
55	11.66	7.13	1.09	0.56	58.92	0.04	17.13	96.54	2a-2a 53 c
56	11.47	6.78	0.12	0.53	59.97	0.00	17.75	96.61	2a-2a 54 c
57	12.02	7.72	0.11	0.57	56.13	0.00	16.14	92.69	2a-2a 55 c
58	11.96	8.27	0.16	0.56	58.74	0.05	16.61	96.35	2a-2a 56 c

Table Spinel. (continued).

No.	MgO	Al2O3	Cr2O3	MnO	FeO	Nb2O5	TiO2	Total	Comment
59	11.62	6.31	2.19	0.60	58.31	0.01	16.94	95.98	2a-2a 57 c
60	12.80	9.96	0.05	0.62	58.11	0.00	15.18	96.72	2a-2a 58 c
61	11.71	8.16	0.04	0.53	59.17	0.04	16.89	96.54	2a-2a 59 c
62	12.04	8.28	0.18	0.50	59.00	0.00	16.57	96.57	2a-2a 60 c
63	11.64	6.75	0.43	0.53	59.89	0.00	17.66	96.91	2a-2a 61 c
64	12.18	8.64	0.09	0.52	58.03	0.00	16.40	95.87	2a-2a 62 c
65	11.00	5.87	2.72	0.53	59.19	0.00	17.18	96.50	2a-2a 63 c
66	12.13	7.00	1.08	0.64	57.90	0.00	17.00	95.76	2a-2a 64 c
67	11.37	6.19	1.62	0.54	58.92	0.00	17.51	96.15	2a-2a 65 c
68	11.92	6.95	0.17	0.51	58.89	0.00	17.57	96.00	2a-2a 66 c
69	11.50	8.27	0.07	0.56	58.28	0.00	16.43	95.12	2a-2a 67 c
70	12.76	9.53	0.03	0.61	58.23	0.00	15.28	96.44	2a-2a 68 c
71	11.35	6.91	1.88	0.52	58.86	0.00	17.09	96.61	2a-2a 69 c
72	12.23	9.34	0.03	0.49	58.33	0.00	16.13	96.55	2a-2a 70 c
73	12.37	7.86	0.21	0.55	59.07	0.00	17.09	97.14	2a-2a 71 c
74	11.79	8.23	0.12	0.53	58.52	0.00	16.60	95.80	2a-2a 72 c
75	10.48	8.32	33.37	0.36	36.94	0.00	6.80	96.27	2a-2a 73 c
76	11.99	8.80	0.05	0.49	58.60	0.00	16.53	96.46	2a-2a 74 c
77	12.78	9.61	0.05	0.61	57.65	0.00	15.82	96.51	2a-2a 75 c
78	11.07	5.88	0.29	0.51	60.38	0.00	18.39	96.52	2a-2a 76 c
79	11.58	7.38	0.12	0.51	59.57	0.00	17.55	96.70	2a-2a 77 c
80	11.52	6.45	0.43	0.56	59.40	0.00	17.80	96.15	2a-2a 78 c
81	11.81	7.17	0.18	0.52	59.04	0.00	17.46	96.19	2a-2a 79 c
82	13.10	10.27	0.14	0.56	56.38	0.01	15.08	95.53	2a-2a 80 c
83	11.81	6.44	0.13	0.59	59.39	0.04	17.81	96.21	2a-2a 81 c
84	13.93	10.41	0.03	0.60	57.17	0.01	15.39	97.53	2a-2a 82 c
85	11.78	6.44	1.52	0.60	59.05	0.08	17.05	96.52	2a-2a 83 c
86	12.46	9.47	0.03	0.58	58.00	0.09	16.13	96.76	2a-2a 84 c
87	12.12	8.59	0.13	0.55	58.41	0.01	16.48	96.29	2a-2a 85 c
88	12.58	8.25	0.37	0.59	58.16	0.00	16.35	96.30	2a-2a 86 c
89	13.69	7.00	0.02	1.19	63.77	0.21	5.53	91.41	2a-2a 86 a
90	12.76	8.80	0.01	0.57	58.44	0.05	15.96	96.58	2a-2a 87 c
91	12.66	7.68	0.23	0.65	58.09	0.05	16.92	96.27	2a-2a 88 c
92	12.26	8.91	0.03	0.56	57.58	0.06	16.32	95.72	2a-2a 89 c
93	12.14	7.20	0.18	0.60	58.05	0.08	17.09	95.33	2a-2a 90 c
94	11.48	6.73	0.14	0.57	59.38	0.06	17.76	96.12	2a-2a 91 c
95	12.00	8.50	5.94	0.57	53.96	0.06	13.84	94.87	2a-2a 92 c
96	11.90	7.81	0.11	0.58	58.56	0.07	17.05	96.07	2a-2a 93 c
97	14.02	11.86	0.01	0.68	55.57	0.04	13.57	95.75	2a-2a 94 c
98	12.78	9.66	0.04	0.66	56.97	0.00	15.40	95.51	2a-2a 95 c
99	15.79	12.43	0.00	0.62	55.32	0.06	14.00	98.21	2a-2a 96 c
100	11.79	8.93	0.24	0.45	58.51	0.03	16.25	96.20	2a-2a 97 c
101	18.47	10.87	0.00	1.01	54.11	0.11	5.96	90.53	2a-2a 97 c
102	12.74	9.07	0.04	0.65	57.30	0.03	15.63	95.45	2a-2a 98 c
103	13.46	11.77	0.02	0.60	56.36	0.04	14.01	96.25	2a-2a 99 c
104	11.92	6.47	0.20	0.57	58.69	0.07	17.53	95.45	2a-2a 100 c
105	12.64	8.22	0.18	0.67	57.55	0.07	16.04	95.37	2a-2a 101 c
106	12.49	9.79	0.04	0.58	57.90	0.02	15.66	96.47	2a-2a 102 c
107	13.83	14.60	0.02	0.69	55.53	0.00	11.19	95.86	2a-2a 103 c
108	15.85	6.99	0.00	1.40	62.35	0.40	5.35	92.35	2a-2a 103 a
109	12.36	7.67	0.16	0.60	58.42	0.03	16.78	96.00	2a-2a 104 c
110	12.14	11.72	0.00	0.55	38.00	0.06	4.28	66.74	2a-2a 104 a
111	12.72	9.12	0.14	0.59	57.60	0.06	15.74	95.96	2a-2a *105 c
112	12.22	6.96	0.21	0.59	58.65	0.03	17.08	95.74	2a-2a *106 c
113	15.10	8.46	0.02	1.17	55.87	0.25	5.17	86.03	2a-2a *106 a
114	15.54	14.61	0.01	0.67	54.19	0.02	12.39	97.43	2a-2a 107 c

Table Spinel. (continued).

No.	MgO	Al2O3	Cr2O3	MnO	FeO	Nb2O5	TiO2	Total	Comment
115	13.66	12.80	0.01	0.65	56.39	0.01	12.09	95.61	2a-2a 108 c
116	16.45	13.07	0.00	0.98	54.43	0.07	7.12	92.13	2a-2a 108 a
117	9.94	7.80	33.84	0.44	36.29	0.01	6.15	94.47	2a-2a *109 c
118	12.19	8.70	0.07	0.55	58.34	0.03	15.92	95.79	2a-2a 110 c
119	16.47	15.37	0.00	0.88	52.51	0.00	7.67	92.90	2a-2a 110 a
120	12.55	10.40	0.03	0.58	57.34	0.04	15.05	95.99	2a-2a 111 c
121	11.63	7.16	0.19	0.58	59.85	0.02	17.55	96.97	2a-2a 112 c
122	12.65	8.47	0.17	0.64	57.95	0.06	16.72	96.67	2a-2a 113 c
123	12.14	7.88	0.16	0.57	58.24	0.00	16.85	95.83	2a-2a 114 c
124	11.80	6.74	0.15	0.55	58.88	0.00	17.65	95.76	2a-2a 115 c
125	13.06	9.80	0.04	0.55	57.02	0.00	15.55	96.03	2a-2a 117 c
126	14.97	4.41	0.02	1.38	56.81	0.42	3.29	81.29	2a-2a 117 a
127	11.43	7.90	0.21	0.52	58.51	0.00	16.96	95.52	2a-2a 118 c
128	11.43	6.67	0.65	0.53	59.04	0.02	17.20	95.53	2a-2a 119 c
129	13.31	11.63	0.02	0.63	55.67	0.00	13.81	95.08	2a-2a 120 c
130	15.74	11.59	0.02	1.05	59.69	0.13	5.65	93.87	2a-2a 120 a
131	12.47	9.94	0.04	0.57	57.16	0.00	14.93	95.10	2a-2a 121 c
132	12.34	10.21	0.02	0.62	57.00	0.00	14.49	94.67	2a-2a 122 c
133	12.87	9.93	0.04	0.63	57.34	0.00	15.00	95.81	2a-2a 123 c
134	11.65	8.53	0.20	0.56	58.66	0.01	16.63	96.22	2a-2a 124 c
135	12.24	11.03	41.09	0.27	27.58	0.02	4.85	97.07	2a-2a 125 c
136	11.21	5.91	0.43	0.55	59.81	0.00	17.84	95.75	2a-2a 126 c
137	11.82	8.91	0.06	0.47	58.10	0.02	16.29	95.65	2a-2a 127 c
138	11.54	6.74	0.50	0.50	58.94	0.00	17.65	95.87	2a-2a 128 c
139	11.34	6.72	0.22	0.54	59.34	0.12	17.80	96.07	2a-2a 129 c
140	12.50	9.43	0.02	0.60	57.02	0.00	15.02	94.58	2a-2a 130 c
141	13.01	10.28	0.03	0.57	56.95	0.00	15.02	95.85	2a-2a 131 c
142	12.35	9.13	0.02	0.57	58.06	0.01	15.49	95.63	2a-2a 132 c
143	11.05	8.41	0.13	0.54	59.26	0.02	16.52	95.92	2a-2a 133 c
144	11.53	8.03	0.21	0.52	59.16	0.00	16.75	96.19	2a-2a 134 c
145	11.33	6.76	0.57	0.56	59.36	0.03	17.61	96.24	2a-2a 135 c
146	12.02	10.91	0.05	0.52	57.29	0.00	15.06	95.84	2a-2a 136 c
147	11.62	7.92	0.17	0.55	58.99	0.02	16.68	95.94	2a-2a 137 c
148	11.64	7.50	0.10	0.55	59.29	0.00	17.28	96.36	2a-2a 138 c
149	11.17	8.01	0.22	0.49	59.31	0.04	16.89	96.14	2a-2a 139 c
150	11.12	8.04	16.36	0.56	48.22	0.00	11.06	95.36	2a-2a 140 c
151	11.58	6.20	0.33	0.60	59.24	0.00	18.16	96.11	2a-2a 141 c
152	11.59	9.28	0.01	0.50	58.62	0.01	16.28	96.29	2a-2a 142 c
153	10.57	6.90	0.38	0.49	60.43	0.06	16.93	95.74	2b-5 1 c
154	12.16	9.66	0.02	0.59	58.59	0.00	14.99	96.00	2b-5 2 c
155	12.73	12.86	0.00	0.61	56.94	0.00	12.59	95.74	2b-5 3 c
156	11.93	13.35	0.00	0.75	59.23	0.00	8.48	93.74	2b-5 3 a
157	12.43	9.54	0.06	0.64	57.53	0.00	14.93	95.13	2b-5 4 c
158	11.33	8.29	0.26	0.51	59.32	0.00	16.06	95.78	2b-5 5 c
159	18.84	7.26	0.00	0.14	21.74	0.00	3.48	51.46	2b-5 5 a
160	13.37	11.25	0.02	0.61	57.21	0.04	14.02	96.51	2b-5 6 c
161	11.99	10.10	0.02	0.55	57.87	0.00	14.57	95.08	2b-5 7 c
162	12.18	8.88	0.18	0.58	58.49	0.00	15.63	95.94	2b-5 8 c
163	19.86	8.62	0.00	0.29	26.21	0.05	4.36	59.38	2b-5 8 a
164	11.62	7.32	0.38	0.58	61.01	0.09	16.89	97.89	2b-5 9 c
165	17.99	16.17	0.06	0.76	43.35	0.13	7.61	86.07	2b-5 9 a
166	11.43	7.62	0.34	0.55	60.15	0.00	16.77	96.85	2b-5 10 c
167	12.07	9.20	0.06	0.65	59.26	0.05	15.34	96.62	2b-5 11 c
168	17.74	18.38	0.02	0.80	45.30	0.15	7.98	90.37	2b-5 11 a
169	18.46	13.57	0.06	0.95	52.94	0.06	8.50	94.52	2b-5 12 a
170	12.31	8.99	0.09	0.65	58.58	0.01	15.49	96.11	2b-5 13 c

Table Spinel. (continued).

No.	MgO	Al2O3	Cr2O3	MnO	FeO	Nb2O5	TiO2	Total	Comment
171	12.38	8.83	0.11	0.67	58.42	0.05	15.70	96.15	2b-5 14 c
172	12.30	8.44	0.27	0.63	58.92	0.11	16.10	96.76	2b-5 15 c
173	11.95	9.12	0.06	0.62	58.80	0.07	16.18	96.79	2b-5 16 c
174	12.10	9.33	0.08	0.59	58.47	0.05	15.47	96.09	2b-5 17 c
175	11.37	7.54	0.42	0.61	59.85	0.06	16.74	96.57	2b-5 18 c
176	12.12	8.25	0.22	0.60	58.89	0.08	16.34	96.50	2b-5 19 c
177	16.90	15.97	0.03	0.63	37.09	0.13	7.12	77.87	2b-5 19 a
178	11.99	8.82	0.06	0.62	58.88	0.07	15.96	96.41	2b-5 20 c
179	12.44	7.57	0.31	0.71	58.98	0.11	16.16	96.27	2b-5 *21 c
180	11.91	7.62	0.31	0.62	59.26	0.04	16.60	96.36	2b-5 *22 c
181	11.66	7.27	0.42	0.58	59.75	0.12	17.03	96.82	2b-5 23 c
182	17.33	17.87	0.05	0.72	43.17	0.15	7.95	87.24	2b-5 23 a
183	11.92	9.68	0.01	0.47	58.25	0.00	15.58	95.91	2b-5 24 c
184	11.81	11.44	0.03	0.39	57.46	0.00	14.77	95.90	2b-5 25 c
185	12.61	9.47	0.04	0.51	58.36	0.02	15.14	96.16	2b-5 26 c
186	17.13	14.69	0.00	0.62	42.31	0.03	7.39	82.17	2b-5 26 a
187	11.71	7.49	0.86	0.52	58.77	0.02	16.64	96.01	2b-5 27 c
188	12.30	8.60	0.12	0.54	58.03	0.05	15.85	95.49	2b-5 28 c
189	12.93	9.37	0.10	0.63	57.53	0.01	15.29	95.84	2b-5 *29 c
190	11.88	8.44	0.17	0.52	58.83	0.03	16.30	96.16	2b-5 30 c
191	12.09	8.38	0.12	0.47	58.89	0.00	16.05	96.00	2b-5 31 c
192	12.01	8.71	0.12	0.49	58.64	0.01	15.99	95.96	2b-5 33 c
193	11.80	8.47	0.11	0.49	58.81	0.00	16.15	95.83	2b-5 34 c
194	12.33	8.81	0.06	0.58	58.32	0.05	15.75	95.90	2b-5 35 c
195	17.24	16.75	0.00	0.54	34.32	0.10	6.62	75.56	2b-5 35 a
196	12.37	8.88	0.17	0.56	58.05	0.05	16.07	96.16	2b-5 36 c
197	11.37	7.02	0.37	0.52	59.71	0.00	16.94	95.91	2b-5 37 c
198	11.09	7.36	0.30	0.46	59.81	0.03	16.88	95.93	2b-5 38 c
199	10.34	8.62	46.47	0.33	28.16	0.05	3.20	97.17	2b-5 *39 c
200	12.11	8.88	0.05	0.50	58.67	0.00	15.87	96.07	2b-5 40 c
201	16.79	16.72	0.00	0.68	44.43	0.04	7.51	86.17	2b-5 40 a
202	11.74	8.09	0.31	0.58	58.45	0.04	16.07	95.28	2b-5 41 c
203	11.85	7.85	0.19	0.54	59.25	0.00	16.51	96.19	2b-5 42 c
204	12.91	9.84	0.00	0.60	57.67	0.03	14.97	96.03	2b-5 43 c
205	12.77	9.01	0.03	0.55	58.44	0.00	15.48	96.28	2b-5 44 c
206	12.48	9.60	0.00	0.52	58.21	0.03	15.32	96.15	2b-5 45 c
207	11.88	8.79	5.67	0.52	55.98	0.07	13.97	96.88	2b-5 46 c
208	12.45	8.02	1.14	0.61	58.73	0.06	15.90	96.90	2b-5 47 c
209	12.34	8.04	0.85	0.56	58.70	0.09	16.06	96.63	2b-5 48 c
210	13.15	10.67	0.00	0.57	57.66	0.00	14.31	96.35	2b-5 49 c
211	18.80	17.11	0.00	0.82	48.22	0.01	8.15	93.12	2b-5 49 a
212	12.34	9.74	0.01	0.56	58.30	0.04	15.07	96.06	2b-5 50 c
213	3.28	0.73	0.00	0.04	5.88	1.92	63.75	75.60	2b-5 50 a
214	12.43	9.74	0.02	0.53	58.22	0.00	15.11	96.05	2b-5 51 c
215	12.31	8.96	0.01	0.56	58.07	0.00	15.58	95.48	2b-5 52 c
216	17.04	21.32	0.00	0.64	42.17	0.09	7.65	88.90	2b-5 52 a
217	11.73	8.27	0.23	0.48	59.62	0.11	16.19	96.62	2b-5 *53 c
218	11.89	8.38	0.09	0.55	58.47	0.01	15.82	95.22	2b-5 *54 c
219	11.76	6.91	2.31	0.56	58.02	0.00	15.94	95.50	2b-5 *55 c
220	11.67	8.15	0.14	0.55	59.90	0.05	16.28	96.74	2b-5 56 c
221	11.43	7.22	0.36	0.51	60.52	0.07	17.09	97.20	2b-5 57 c
222	12.49	9.05	0.02	0.62	58.62	0.01	15.59	96.40	2b-5 58 c
223	11.73	7.52	0.33	0.53	59.49	0.00	16.13	95.73	2b-5 59 c
224	11.16	7.38	0.29	0.50	59.91	0.05	16.31	95.60	2b-5 60 c
225	11.55	8.45	0.06	0.52	59.34	0.02	16.10	96.05	2b-5 61 c
226	10.90	6.95	8.29	0.48	55.57	0.04	13.70	95.93	2b-5 62 c

Table Spinel. (continued).

No.	MgO	Al2O3	Cr2O3	MnO	FeO	Nb2O5	TiO2	Total	Comment
227	11.80	9.14	0.04	0.53	58.08	0.01	14.99	94.58	2b-5 63 c
228	16.92	19.55	0.00	0.70	44.92	0.05	7.38	89.52	2b-5 63 a
229	12.03	9.24	0.03	0.57	58.29	0.00	14.93	95.09	2b-5 64 c
230	11.83	9.27	0.07	0.53	58.94	0.00	14.84	95.48	2b-5 65 c
231	11.18	7.38	0.23	0.50	59.87	0.06	16.22	95.43	2b-5 66 c
232	11.41	8.34	0.13	0.51	58.27	0.07	16.04	94.77	2b-5 67 c
233	11.80	8.20	0.21	0.53	58.71	0.00	15.93	95.37	2b-5 68 c
234	11.88	9.14	0.00	0.52	58.32	0.00	15.23	95.10	2b-5 69 c
235	11.28	8.07	0.24	0.54	59.36	0.03	15.99	95.50	2b-5 70 c
236	9.88	8.31	47.55	0.37	27.38	0.03	2.73	96.25	2b-5 71 c
237	12.00	8.99	0.12	0.58	58.60	0.03	15.31	95.62	2b-5 72 c
238	11.63	9.44	0.00	0.51	59.03	0.02	15.18	95.81	2b-5 74 c
239	11.64	8.88	0.01	0.54	58.26	0.00	15.09	94.42	2b-5 *75 c
240	11.91	9.27	0.01	0.58	58.53	0.07	14.42	94.80	2b-5 76 c
241	10.92	7.14	1.10	0.53	58.93	0.00	16.10	94.73	2b-5 77 c
242	11.37	9.08	0.08	0.50	58.90	0.00	15.48	95.40	2b-5 78 c
243	11.99	9.30	0.01	0.52	58.94	0.05	15.71	96.53	2b-5 79 c
244	10.68	8.32	28.17	0.41	41.77	0.01	7.51	96.85	2b-5 80 c
245	12.03	8.16	0.17	0.54	59.32	0.05	16.15	96.42	2b-5 81 c
246	11.99	7.76	0.21	0.54	59.11	0.06	16.53	96.20	2b-5 81 c
247	11.69	8.47	0.04	0.48	59.75	0.08	16.38	96.90	2b-5 82 c
248	12.07	7.66	3.17	0.53	57.42	0.04	15.18	96.07	2b-5 83 c
249	12.83	8.57	7.36	0.62	53.01	0.05	12.47	94.91	2b-5 84 c
250	11.22	6.64	1.54	0.48	60.11	0.05	16.80	96.85	2b-5 85 c
251	12.73	9.32	0.07	0.60	58.25	0.01	15.03	96.02	2b-5 86 c
252	12.37	9.22	0.03	0.52	58.65	0.03	15.56	96.37	2b-5 87 c
253	18.16	12.32	0.00	0.41	32.89	0.04	5.69	69.50	2b-5 87 a
254	18.05	12.48	0.00	0.84	52.85	0.07	9.01	93.29	2b-5 88 a
255	12.36	9.44	0.03	0.55	58.39	0.06	15.17	96.01	2b-5 88 c
256	11.99	7.36	0.52	0.58	58.80	0.03	16.59	95.86	2b-5 89 c
257	12.26	9.07	0.04	0.57	58.77	0.01	15.62	96.34	2b-5 90 c
258	12.45	8.98	0.18	0.61	58.67	0.05	15.77	96.70	2b-5 91 c
259	12.48	10.19	0.06	0.52	58.03	0.05	14.88	96.20	2b-5 92 c
260	11.98	8.43	0.09	0.52	58.76	0.02	16.21	96.00	2b-5 93 c
261	12.68	9.31	0.05	0.62	57.91	0.00	15.25	95.82	2b-5 94 c
262	11.52	6.76	1.14	0.53	59.78	0.07	16.94	96.74	2b-5 95 c
263	11.71	8.67	0.08	0.57	58.66	0.00	15.97	95.66	2b-5 96 c
264	12.47	9.66	0.05	0.54	58.34	0.01	15.38	96.44	2b-5 97 c
265	11.16	7.27	0.34	0.54	60.14	0.05	17.04	96.54	2b-5 98 c
266	11.20	7.65	0.46	0.53	60.13	0.01	16.86	96.84	2b-5 99 c
267	11.83	8.21	0.27	0.55	59.53	0.00	16.33	96.71	2b-5 100 c
268	11.90	8.94	0.07	0.55	58.89	0.00	15.76	96.11	2b-5 101 c
269	12.19	8.75	0.06	0.58	58.44	0.00	15.86	95.88	2b-5 102 c
270	11.06	6.31	0.46	0.49	61.07	0.00	17.51	96.88	2b-5 103 c
271	12.27	9.10	0.05	0.60	59.01	0.00	15.25	96.28	2b-5 104 c
272	11.62	8.82	0.12	0.53	59.31	0.00	15.97	96.37	2b-5 105 c
273	11.42	8.11	0.24	0.46	59.60	0.01	16.59	96.41	2b-5 105 c
274	12.28	9.42	0.05	0.56	58.06	0.05	15.11	95.52	2b-5 106 c
275	11.19	6.79	2.02	0.54	59.32	0.01	16.45	96.31	2b-5 107 c
276	12.18	8.32	0.30	0.62	58.74	0.00	16.18	96.35	2b-5 109 c
277	11.37	7.38	0.32	0.54	60.00	0.03	16.98	96.61	2b-5 110 c
278	11.71	8.56	0.06	0.56	59.37	0.00	16.37	96.63	2b-5 111 c
279	11.57	8.77	0.03	0.50	59.17	0.00	16.12	96.16	2b-5 112 c
280	11.31	7.43	0.35	0.53	59.79	0.00	16.79	96.20	2b-5 113 c
281	11.91	8.44	0.04	0.56	59.29	0.00	16.29	96.54	2b-5 114 c
282	11.81	7.48	0.32	0.57	59.18	0.02	16.48	95.86	2b-5 115 c

Table Spinel. (continued).

No.	MgO	Al2O3	Cr2O3	MnO	FeO	Nb2O5	TiO2	Total	Comment
283	11.66	8.06	0.20	0.52	59.02	0.03	16.55	96.04	2b-5 116c
284	16.82	12.70	0.00	0.42	31.05	0.00	5.84	66.83	2b-5 116a
285	11.71	8.17	0.25	0.53	58.74	0.00	16.26	95.64	2b-5 117c
286	12.61	9.53	0.00	0.62	57.98	0.00	15.01	95.74	2b-5 118c
287	11.87	8.69	0.03	0.52	58.15	0.00	16.21	95.46	2b-5 119c
288	12.62	9.32	0.02	0.63	56.87	0.00	15.17	94.64	2b-5 120c
289	11.95	8.89	0.08	0.53	58.01	0.00	15.94	95.41	2b-5 121c
290	11.71	7.98	0.17	0.54	58.48	0.03	16.64	95.54	2b-5 122c
291	12.60	9.50	0.01	0.60	57.91	0.00	15.52	96.15	2b-5 123c
292	11.49	6.94	0.57	0.54	59.07	0.00	16.99	95.59	2b-5 125c
293	12.02	8.45	0.08	0.58	58.22	0.00	15.89	95.24	2b-5 126c
294	11.13	6.03	1.00	0.55	59.81	0.00	17.40	95.92	2b-5 127c
295	11.57	8.07	0.19	0.55	58.39	0.04	16.09	94.90	2b-5 128c
296	11.37	7.53	0.32	0.49	59.37	0.00	16.88	95.96	2b-5 129c
297	11.60	9.14	0.03	0.53	58.64	0.00	15.92	95.85	2b-5 130c
298	11.73	7.48	0.23	0.63	59.14	0.00	15.87	95.06	2b-5 131c
299	12.10	9.04	0.02	0.55	57.83	0.03	15.63	95.20	2b-5 132c
300	12.26	9.15	0.02	0.60	57.92	0.00	15.69	95.63	2b-5 *133c
301	11.12	8.10	0.26	0.44	58.68	0.00	16.13	94.74	2b-5 *134c
302	12.64	9.39	0.05	0.64	57.07	0.06	15.28	95.12	2b-5 135c
303	12.84	6.37	0.00	0.68	57.32	0.00	17.50	94.70	upper 1 c1
304	11.82	4.51	0.00	0.63	59.10	0.00	19.02	95.07	upper 1 c2
305	11.45	3.90	0.06	0.56	59.59	0.00	19.51	95.08	upper 1 c3
306	11.97	4.09	0.33	0.68	58.68	0.01	19.14	94.89	upper 2 c1
307	12.29	4.50	0.00	0.71	59.07	0.00	18.66	95.22	upper 2 c2
308	8.30	3.75	0.00	0.97	71.77	0.01	8.08	92.88	upper 2 r1
309	7.72	3.28	0.00	1.02	74.04	0.07	6.11	92.23	upper 2 r2
310	8.93	4.98	0.00	0.84	69.26	0.00	8.67	92.67	upper 3 r1
311	8.37	4.54	0.00	0.88	72.24	0.01	6.36	92.40	upper 3 r2
312	12.28	5.28	0.00	0.68	58.95	0.00	17.99	95.17	upper 3 c1
313	12.85	5.56	0.00	0.71	58.24	0.00	17.58	94.93	upper 3 c2
314	12.50	5.34	0.00	0.64	58.78	0.00	18.15	95.41	upper 4 c1
315	12.62	5.51	0.00	0.71	58.65	0.00	18.05	95.53	upper 4 c2
316	7.95	3.97	0.00	0.90	72.96	0.01	7.16	92.95	upper 4 a1
317	9.29	5.97	0.00	1.04	70.17	0.00	6.43	92.90	upper 4 a2
318	9.94	5.49	0.00	0.84	65.75	0.06	11.36	93.44	upper 5 r1
319	8.93	3.87	0.00	0.85	69.09	0.00	10.62	93.36	upper 5 r2
320	12.61	4.62	0.01	0.67	58.78	0.00	19.02	95.71	upper 5 c1
321	12.38	4.77	0.06	0.66	59.26	0.00	18.60	95.72	upper 5 c2
322	12.09	4.48	0.00	0.68	58.94	0.00	18.86	95.05	upper 6 c1
323	11.71	4.03	0.09	0.74	58.92	0.09	19.00	94.58	upper 6 c2
324	11.64	4.14	0.00	0.67	60.15	0.06	18.46	95.12	upper 7 c1
325	11.45	4.13	0.00	0.68	59.71	0.08	19.01	95.05	upper 7 c2
326	12.33	5.04	0.00	0.74	58.64	0.06	18.10	94.92	upper 8 c1
327	12.83	5.74	0.00	0.73	58.22	0.02	17.71	95.26	upper 8 c2
328	7.45	2.97	0.00	1.02	75.24	0.13	6.33	93.15	upper 8 r1
329	7.20	2.79	0.02	0.99	75.14	0.12	6.56	92.82	upper 8 r2
330	11.35	4.34	0.00	0.61	59.57	0.07	18.92	94.86	upper 9 c1
331	11.89	4.45	0.02	0.65	59.30	0.08	18.62	95.02	upper 9 c2
332	12.21	4.59	0.07	0.70	59.22	0.08	18.61	95.48	upper 10 c1
333	11.84	4.15	0.10	0.68	59.16	0.06	19.11	95.09	upper 10 c2
334	12.69	6.06	0.00	0.74	57.98	0.09	16.96	94.52	upper 11 c1
335	12.08	4.72	0.01	0.68	59.21	0.06	18.46	95.21	upper 11 c2
336	5.50	1.11	0.00	1.76	76.33	0.10	4.26	89.06	upper 11 r1
337	11.90	4.14	0.05	0.68	58.93	0.04	19.07	94.82	upper 12 c1
338	11.73	3.80	0.28	0.62	59.57	0.08	19.36	95.43	upper 12 c2

Table Spinel. (continued).

No.	MgO	Al2O3	Cr2O3	MnO	FeO	Nb2O5	TiO2	Total	Comment
339	12.30	4.63	0.00	0.82	59.01	0.06	18.46	95.29	upper 13 c1
340	12.48	4.96	0.01	0.70	58.36	0.07	18.28	94.87	upper 13 c2
341	12.72	5.91	0.00	0.68	57.83	0.00	17.60	94.74	upper 14 c1
342	12.64	5.61	0.00	0.71	58.13	0.06	18.22	95.37	upper 14 c2
343	11.95	4.68	0.03	0.66	59.42	0.01	19.04	95.78	upper 15 c1
344	11.56	3.89	1.38	0.66	59.05	0.03	19.40	95.97	upper 15 c2
345	11.72	3.95	0.11	0.59	59.79	0.01	19.78	95.94	upper 16 c1
346	12.02	4.46	0.03	0.67	59.16	0.02	19.17	95.53	upper 16 c2
347	12.57	5.60	0.05	0.74	58.54	0.02	18.26	95.78	upper 17 c 1
348	12.45	4.64	1.12	0.72	58.15	0.04	18.34	95.45	upper 17 c2
349	11.05	3.93	0.39	0.65	59.85	0.00	19.68	95.54	upper 18 c1
350	12.17	5.05	0.02	0.66	59.37	0.10	18.84	96.21	upper 18 c2
351	11.83	4.64	0.00	0.63	59.27	0.00	19.11	95.48	upper 19 c1
352	12.04	4.81	0.01	0.65	59.25	0.01	18.99	95.76	upper 19 c2
353	8.20	4.09	0.05	0.92	72.14	0.07	7.27	92.74	upper 19 a1
354	6.55	0.99	0.01	2.29	77.11	0.26	2.85	90.06	upper 19 a2
355	6.44	0.52	0.01	1.90	78.26	0.09	4.97	92.19	upper 20 a1
356	7.86	3.87	0.01	0.95	72.53	0.09	7.56	92.88	upper 20 a2
357	11.81	4.19	0.10	0.68	59.76	0.02	19.39	95.95	upper 20 c1
358	12.24	5.02	0.03	0.71	58.18	0.07	18.85	95.09	upper 20 c2
359	12.36	5.27	0.04	0.69	58.93	0.01	18.62	95.91	upper 21 c1
360	12.29	5.14	0.00	0.72	58.82	0.00	18.72	95.69	upper 21 c2
361	8.80	4.66	0.04	0.90	69.90	0.01	9.42	93.72	upper 21 a1
362	7.32	2.66	0.04	1.27	74.56	0.05	6.82	92.71	upper 21 a2
363	11.91	4.20	0.01	0.78	59.35	0.00	19.32	95.57	upper 22 c1
364	11.93	4.05	0.04	0.80	59.58	0.00	19.49	95.89	upper 22 c2
365	8.00	4.20	0.03	0.97	71.94	0.00	8.11	93.25	upper 22 r1
366	8.20	4.24	0.01	0.92	71.87	0.00	7.94	93.19	upper 22 r2
367	8.22	4.38	0.01	0.99	72.13	0.04	6.22	91.98	upper 23 r1
368	11.99	4.98	0.03	0.60	59.59	0.01	18.90	96.10	upper 23 c1
369	11.59	4.14	0.01	0.65	60.00	0.00	19.62	96.02	upper 24 c1
370	11.99	4.70	0.01	0.62	59.77	0.01	19.39	96.47	upper 24 c2
371	12.66	6.14	0.03	0.68	58.26	0.00	17.75	95.51	upper 25 c1
372	12.89	6.79	0.01	0.69	58.40	0.04	17.14	95.96	upper 25 c2
373	8.28	4.17	0.03	1.01	73.03	0.02	6.70	93.24	upper 25 r1
374	9.34	4.74	0.00	0.87	68.23	0.03	10.90	94.11	upper 25 r2
375	12.18	4.84	0.02	0.64	58.86	0.05	18.93	95.52	upper 26 c1
376	12.26	4.64	0.00	0.68	59.17	0.02	19.04	95.81	upper 26 c2
377	10.81	8.55	45.56	0.36	28.59	0.00	4.27	98.15	upper 27 c1
378	10.86	8.66	45.44	0.39	28.39	0.00	4.13	97.85	upper 27 c2
379	12.24	5.10	0.02	0.70	58.91	0.04	18.96	95.97	upper 28 c1
380	12.54	5.63	0.01	0.71	58.80	0.08	18.21	95.98	upper 28 c2
381	4.98	0.06	0.05	2.01	79.60	0.05	5.62	92.36	upper 28 r1
382	9.12	4.91	0.01	0.83	69.15	0.10	9.80	93.91	upper 28 r2
383	12.02	4.72	0.01	0.63	58.89	0.08	19.09	95.43	upper 29 c1
384	12.09	5.03	0.03	0.66	59.07	0.05	18.65	95.57	upper 30 c1
385	11.67	4.68	0.03	0.61	60.17	0.11	18.79	96.06	upper 31 c1
386	10.84	4.16	4.76	0.64	57.27	0.06	17.20	94.93	upper 32 c1
387	10.95	4.02	2.17	0.59	59.38	0.07	18.42	95.59	upper 33 c1
388	12.31	4.23	0.16	0.73	59.09	0.07	19.42	96.01	upper 34 c1
389	12.33	4.50	0.06	0.71	58.63	0.10	18.64	94.95	upper 35 c1
390	11.15	4.17	0.04	0.62	59.96	0.12	19.46	95.52	upper 36 c1
391	12.44	5.70	0.04	0.74	58.30	0.11	17.80	95.12	upper 37 c1
392	12.36	5.64	0.02	0.74	59.09	0.10	17.83	95.77	upper 37 c2
393	11.71	4.24	0.03	0.63	59.27	0.07	19.33	95.28	upper 38 c1

Table Spinel. (continued).

No.	MgO	Al2O3	Cr2O3	MnO	FeO	Nb2O5	TiO2	Total	Comment
394	11.57	4.03	1.07	0.64	59.60	0.10	19.02	96.03	upper 38 c2
395	11.88	4.20	0.09	0.65	59.29	0.10	18.76	94.97	upper 39 c1
396	11.60	4.18	0.45	0.67	59.77	0.10	19.08	95.86	upper 40 c1
397	11.94	4.33	0.21	0.64	59.45	0.10	19.20	95.88	upper 41 c1
398	12.05	4.42	0.06	0.72	59.44	0.06	18.75	95.50	upper 42 c1
399	8.62	4.64	0.01	0.91	71.13	0.07	8.28	93.65	upper 42 r1
400	12.32	4.46	0.17	0.76	58.78	0.10	18.86	95.45	upper 43 c1
401	12.23	5.45	0.02	0.64	58.45	0.11	18.08	94.98	upper 44 c1
402	12.40	6.51	0.00	0.82	58.77	0.09	16.25	94.84	upper 45 c1
403	12.32	5.13	0.01	0.71	58.52	0.02	17.66	94.37	upper 46 c1
404	11.70	4.62	0.01	0.62	59.62	0.01	18.28	94.86	upper 47 c1
405	12.27	4.83	0.02	0.66	59.08	0.00	17.95	94.82	upper 48 c1
406	7.68	3.88	0.03	0.90	72.68	0.05	7.39	92.61	upper 48 a1
407	11.22	6.82	27.26	0.56	41.83	0.05	8.69	96.42	upper 49 c1
408	0.09	0.03	0.05	0.05	58.03	0.10	0.05	58.40	upper 50 c1
409	11.36	4.06	0.09	0.60	59.83	0.00	18.57	94.50	upper 51 c1
410	11.74	4.10	0.12	0.63	58.81	0.00	18.58	93.97	upper 52 c1
411	12.14	5.20	0.03	0.65	58.40	0.03	17.48	93.92	upper 53 c1
412	11.46	3.99	0.25	0.61	60.04	0.03	18.61	94.98	upper 54 c1
413	12.25	6.27	0.03	0.69	58.91	0.05	16.38	94.57	upper 55 c1
414	8.13	4.08	0.02	0.93	72.16	0.02	7.73	93.06	upper 55 a1
415	11.18	3.99	1.51	0.56	59.32	0.00	18.26	94.83	upper 56 c1
416	11.68	4.28	0.13	0.63	59.59	0.02	18.22	94.55	upper 56 c7
417	12.09	4.36	0.13	0.69	59.07	0.03	18.25	94.62	upper 57 c1
418	8.91	4.83	0.02	0.87	68.70	0.09	8.88	92.30	upper 57 a1
419	10.90	3.86	1.64	0.54	60.14	0.04	18.09	95.21	upper 58 c1
420	12.54	8.19	0.02	0.71	58.65	0.01	14.42	94.53	upper 59 c1
421	7.79	4.08	0.04	0.92	73.46	0.03	7.22	93.53	upper 59 r1
422	11.29	3.92	0.51	0.60	59.88	0.03	18.61	94.85	upper 60 c1
423	12.42	6.08	0.00	0.70	58.51	0.00	17.81	95.51	upper 61 c1
424	12.69	6.57	0.01	0.69	59.01	0.00	17.31	96.26	upper 61 c2
425	11.68	4.25	4.57	0.63	57.33	0.00	17.29	95.74	upper 62 c1
426	11.86	3.93	0.48	0.65	59.49	0.00	19.59	96.00	upper 62 c2
427	12.26	7.25	0.03	0.74	60.64	0.00	14.56	95.47	upper 63 c1
428	12.59	5.67	0.00	0.71	58.37	0.00	18.14	95.48	upper 64 c1
429	11.69	4.34	0.00	0.62	59.54	0.00	19.47	95.67	upper 65 c1
430	11.84	4.63	0.05	0.66	60.59	0.00	18.39	96.17	upper 66 c1

Table Spinel. Sructural formula based on 4 oxygens.

No.	Mg	Al	Cr	Mn	Fe	Nb	Ti	Total	Comment
3	0.636	0.294	0.003	0.018	1.882	0.000	0.509	3.342	2a 1c
4	0.624	0.319	0.006	0.016	1.877	0.000	0.498	3.339	2a 2 c
5	0.645	0.297	0.003	0.018	1.876	0.000	0.506	3.344	2a 3 c
6	0.601	0.253	0.062	0.016	1.885	0.000	0.512	3.330	2a 4 c
7	0.638	0.360	0.006	0.016	1.838	0.000	0.479	3.337	2a 5 c
8	0.647	0.351	0.007	0.019	1.851	0.000	0.473	3.348	2a 6 c
9	0.674	0.358	0.003	0.017	1.829	0.000	0.469	3.350	2a 7 c
10	0.649	0.409	0.000	0.017	1.816	0.000	0.452	3.343	2a 8 c
11	0.687	0.425	0.001	0.018	1.802	0.000	0.428	3.360	2a-2a 9 c
12	0.657	0.369	0.004	0.017	1.838	0.000	0.464	3.349	2a-2a 10 c
13	0.663	0.345	0.003	0.019	1.835	0.000	0.481	3.345	2a-2a 11 c
14	0.706	0.426	0.000	0.019	1.787	0.000	0.424	3.363	2a-2a 12 c
15	0.629	0.386	0.001	0.016	1.845	0.000	0.464	3.342	2a-2a 13 c
16	0.689	0.440	0.000	0.018	1.780	0.000	0.426	3.354	2a-2a 14 c
17	0.639	0.300	0.003	0.017	1.874	0.000	0.508	3.341	2a-2a 15 c
18	0.639	0.294	0.014	0.019	1.867	0.001	0.506	3.339	2a-2a 16 c
19	0.703	0.436	0.000	0.021	1.783	0.000	0.420	3.362	2a-2a 17 c
20	0.614	0.278	0.014	0.018	1.892	0.000	0.519	3.335	2a-2a 18 c
21	0.612	0.300	0.002	0.016	1.898	0.001	0.510	3.338	2a-2a 19 c
22	0.688	0.444	0.000	0.019	1.787	0.000	0.420	3.358	2a-2a 20 c
23	0.747	0.463	0.000	0.019	1.721	0.001	0.408	3.359	2a-2a 21 c
24	0.930	0.476	0.000	0.032	1.813	0.002	0.254	3.506	2a-2a 21 a
25	0.661	0.433	0.001	0.017	1.783	0.000	0.445	3.339	2a-2a 22 c
26	0.724	0.483	0.001	0.021	1.733	0.000	0.399	3.359	2a-2a 23 c
27	0.636	0.287	0.002	0.016	1.889	0.000	0.513	3.342	2a-2a 24 c
28	0.685	0.425	0.000	0.016	1.785	0.001	0.437	3.349	2a-2a 25 c
29	0.656	0.374	0.004	0.017	1.826	0.001	0.466	3.344	2a-2a 26 c
30	0.652	0.306	0.006	0.020	1.859	0.000	0.501	3.344	2a-2a 27 c
31	0.534	0.371	1.095	0.013	0.985	0.000	0.135	3.132	2a-2a 29 c
32	0.721	0.450	0.000	0.020	1.758	0.000	0.413	3.362	2a-2a 30 c
33	0.670	0.349	0.004	0.019	1.833	0.001	0.474	3.348	2a-2a 31 c
34	0.658	0.386	0.002	0.018	1.809	0.000	0.467	3.339	2a-2a 32 c
35	0.666	0.389	0.000	0.018	1.819	0.000	0.457	3.348	2a-2a 33 c
36	0.690	0.454	0.001	0.018	1.761	0.000	0.424	3.348	2a-2a 34 c
37	0.644	0.301	0.009	0.017	1.870	0.000	0.502	3.343	2a-2a 35 c
38	0.663	0.398	0.001	0.017	1.817	0.000	0.452	3.348	2a-2a 36 c
39	0.682	0.346	0.007	0.018	1.830	0.000	0.470	3.354	2a-2a 37 c
40	0.740	0.484	0.002	0.022	1.727	0.001	0.390	3.366	2a-2a 38 c
41	0.642	0.288	0.011	0.019	1.875	0.001	0.507	3.342	2a-2a 39 c
42	0.663	0.408	0.001	0.017	1.805	0.000	0.450	3.345	2a-2a 40 c
43	0.696	0.480	0.000	0.016	1.747	0.000	0.411	3.349	2a-2a 41 c
44	0.664	0.300	0.003	0.017	1.872	0.000	0.497	3.352	2a-2a 42 c
45	0.647	0.313	0.005	0.019	1.871	0.000	0.494	3.348	2a-2a 43 c
46	0.679	0.401	0.001	0.019	1.823	0.000	0.438	3.361	2a-2a 44 c
47	0.652	0.359	0.004	0.017	1.850	0.000	0.468	3.350	2a-2a 45 c
48	0.621	0.253	0.055	0.018	1.891	0.000	0.503	3.342	2a-2a 46 c
49	0.691	0.432	0.003	0.018	1.784	0.000	0.427	3.356	2a-2a 47 c
50	0.711	0.435	0.001	0.019	1.786	0.000	0.415	3.367	2a-2a 48 c
51	0.652	0.278	0.004	0.018	1.900	0.000	0.504	3.355	2a-2a 49 c
52	0.662	0.286	0.050	0.020	1.846	0.000	0.484	3.348	2a-2a 50 c
53	0.696	0.387	0.005	0.020	1.793	0.000	0.452	3.352	2a-2a 51 c
54	0.692	0.428	0.001	0.019	1.804	0.000	0.421	3.365	2a-2a 52 c
55	0.651	0.315	0.032	0.018	1.845	0.001	0.482	3.343	2a-2a 53 c
56	0.642	0.300	0.004	0.017	1.883	0.000	0.501	3.347	2a-2a 54 c
57	0.693	0.352	0.003	0.019	1.816	0.000	0.470	3.353	2a-2a 55 c

Table Spinel. (continued).

No.	Mg	Al	Cr	Mn	Fe	Nb	Ti	Total	Comment
58	0.665	0.363	0.005	0.018	1.832	0.001	0.466	3.349	2a-2a 56 c
59	0.655	0.281	0.066	0.019	1.843	0.000	0.481	3.345	2a-2a 57 c
60	0.702	0.432	0.002	0.019	1.788	0.000	0.420	3.363	2a-2a 58 c
61	0.651	0.359	0.001	0.017	1.845	0.001	0.473	3.346	2a-2a 59 c
62	0.668	0.363	0.005	0.016	1.836	0.000	0.464	3.352	2a-2a 60 c
63	0.649	0.298	0.013	0.017	1.874	0.000	0.497	3.348	2a-2a 61 c
64	0.678	0.380	0.003	0.017	1.811	0.000	0.460	3.348	2a-2a 62 c
65	0.620	0.262	0.081	0.017	1.872	0.000	0.489	3.340	2a-2a 63 c
66	0.680	0.310	0.032	0.021	1.823	0.000	0.481	3.347	2a-2a 64 c
67	0.640	0.276	0.048	0.017	1.862	0.000	0.498	3.341	2a-2a 65 c
68	0.668	0.308	0.005	0.016	1.852	0.000	0.497	3.347	2a-2a 66 c
69	0.648	0.369	0.002	0.018	1.843	0.000	0.467	3.347	2a-2a 67 c
70	0.704	0.416	0.001	0.019	1.802	0.000	0.425	3.367	2a-2a 68 c
71	0.634	0.305	0.056	0.017	1.845	0.000	0.482	3.338	2a-2a 69 c
72	0.674	0.407	0.001	0.015	1.803	0.000	0.448	3.348	2a-2a 70 c
73	0.682	0.343	0.006	0.017	1.827	0.000	0.475	3.350	2a-2a 71 c
74	0.660	0.364	0.003	0.017	1.836	0.000	0.468	3.348	2a-2a 72 c
75	0.561	0.352	0.948	0.011	1.110	0.000	0.184	3.166	2a-2a 73 c
76	0.663	0.385	0.002	0.015	1.819	0.000	0.461	3.345	2a-2a 74 c
77	0.701	0.417	0.001	0.019	1.776	0.000	0.438	3.353	2a-2a 75 c
78	0.624	0.262	0.009	0.016	1.909	0.000	0.523	3.342	2a-2a 76 c
79	0.645	0.325	0.004	0.016	1.861	0.000	0.493	3.343	2a-2a 77 c
80	0.648	0.287	0.013	0.018	1.875	0.000	0.505	3.345	2a-2a 78 c
81	0.661	0.317	0.005	0.017	1.853	0.000	0.493	3.346	2a-2a 79 c
82	0.722	0.448	0.004	0.017	1.744	0.000	0.419	3.355	2a-2a 80 c
83	0.663	0.286	0.004	0.019	1.872	0.001	0.505	3.349	2a-2a 81 c
84	0.750	0.443	0.001	0.018	1.728	0.000	0.418	3.359	2a-2a 82 c
85	0.661	0.285	0.045	0.019	1.857	0.001	0.482	3.351	2a-2a 83 c
86	0.684	0.411	0.001	0.018	1.785	0.002	0.446	3.346	2a-2a 84 c
87	0.672	0.377	0.004	0.017	1.817	0.000	0.461	3.348	2a-2a 85 c
88	0.698	0.362	0.011	0.019	1.810	0.000	0.458	3.356	2a-2a 86 c
89	0.853	0.345	0.001	0.042	2.229	0.004	0.174	3.647	2a-2a 86 a
90	0.705	0.384	0.000	0.018	1.810	0.001	0.445	3.362	2a-2a 87 c
91	0.703	0.337	0.007	0.020	1.810	0.001	0.474	3.353	2a-2a 88 c
92	0.681	0.392	0.001	0.018	1.795	0.001	0.458	3.345	2a-2a 89 c
93	0.684	0.321	0.005	0.019	1.834	0.001	0.486	3.349	2a-2a 90 c
94	0.645	0.299	0.004	0.018	1.872	0.001	0.504	3.343	2a-2a 91 c
95	0.672	0.376	0.177	0.018	1.696	0.001	0.391	3.331	2a-2a 92 c
96	0.664	0.344	0.003	0.018	1.834	0.001	0.480	3.345	2a-2a 93 c
97	0.765	0.511	0.000	0.021	1.699	0.001	0.373	3.370	2a-2a 94 c
98	0.708	0.424	0.001	0.021	1.772	0.000	0.431	3.357	2a-2a 95 c
99	0.830	0.517	0.000	0.018	1.632	0.001	0.371	3.369	2a-2a 96 c
100	0.654	0.392	0.007	0.014	1.822	0.001	0.455	3.345	2a-2a 97 c
101	1.080	0.503	0.000	0.034	1.776	0.002	0.176	3.570	2a-2a 97 c
102	0.709	0.399	0.001	0.021	1.790	0.001	0.439	3.360	2a-2a 98 c
103	0.732	0.506	0.001	0.019	1.719	0.001	0.384	3.361	2a-2a 99 c
104	0.674	0.289	0.006	0.018	1.862	0.001	0.500	3.351	2a-2a 100 c
105	0.708	0.364	0.005	0.021	1.808	0.001	0.453	3.361	2a-2a 101 c
106	0.687	0.426	0.001	0.018	1.786	0.000	0.434	3.352	2a-2a 102 c
107	0.748	0.624	0.001	0.021	1.684	0.000	0.305	3.383	2a-2a 103 c
108	0.966	0.337	0.000	0.049	2.132	0.007	0.164	3.656	2a-2a 103 a
109	0.690	0.338	0.005	0.019	1.830	0.000	0.473	3.355	2a-2a 104 c
110	0.933	0.713	0.000	0.024	1.639	0.001	0.166	3.476	2a-2a 104 a
111	0.705	0.399	0.004	0.019	1.790	0.001	0.440	3.357	2a-2a *105 c

Table Spinel. (continued).

No.	Mg	Al	Cr	Mn	Fe	Nb	Ti	Total	Comment
112	0.687	0.310	0.006	0.019	1.850	0.001	0.485	3.357	2a-2a *106 c
113	0.965	0.428	0.001	0.043	2.004	0.005	0.167	3.612	2a-2a *106 a
114	0.816	0.607	0.000	0.020	1.597	0.000	0.328	3.368	2a-2a 107 c
115	0.748	0.554	0.000	0.020	1.732	0.000	0.334	3.389	2a-2a 108 c
116	0.936	0.588	0.000	0.032	1.738	0.001	0.205	3.500	2a-2a 108 a
117	0.545	0.338	0.984	0.014	1.117	0.000	0.170	3.168	2a-2a *109 c
118	0.680	0.384	0.002	0.017	1.826	0.000	0.448	3.358	2a-2a 110 c
119	0.910	0.672	0.000	0.028	1.628	0.000	0.214	3.450	2a-2a 110 a
120	0.691	0.453	0.001	0.018	1.772	0.001	0.418	3.354	2a-2a 111 c
121	0.647	0.315	0.006	0.018	1.868	0.000	0.493	3.347	2a-2a 112 c
122	0.697	0.369	0.005	0.020	1.790	0.001	0.465	3.347	2a-2a 113 c
123	0.678	0.348	0.005	0.018	1.825	0.000	0.475	3.349	2a-2a 114 c
124	0.664	0.300	0.005	0.018	1.859	0.000	0.501	3.347	2a-2a 115 c
125	0.718	0.426	0.001	0.017	1.760	0.000	0.432	3.355	2a-2a 117 c
126	1.059	0.247	0.001	0.056	2.256	0.009	0.118	3.745	2a-2a 117 a
127	0.642	0.351	0.006	0.016	1.844	0.000	0.481	3.341	2a-2a 118 c
128	0.647	0.298	0.019	0.017	1.875	0.000	0.491	3.349	2a-2a 119 c
129	0.733	0.507	0.001	0.020	1.720	0.000	0.384	3.363	2a-2a 120 c
130	0.907	0.528	0.001	0.034	1.931	0.002	0.164	3.568	2a-2a 120 a
131	0.695	0.438	0.001	0.018	1.788	0.000	0.420	3.360	2a-2a 121 c
132	0.691	0.452	0.001	0.020	1.791	0.000	0.409	3.364	2a-2a 122 c
133	0.711	0.434	0.001	0.020	1.779	0.000	0.418	3.364	2a-2a 123 c
134	0.648	0.375	0.006	0.018	1.830	0.000	0.467	3.343	2a-2a 124 c
135	0.623	0.444	1.110	0.008	0.788	0.000	0.125	3.098	2a-2a 125 c
136	0.637	0.266	0.013	0.018	1.906	0.000	0.511	3.350	2a-2a 126 c
137	0.659	0.393	0.002	0.015	1.817	0.000	0.458	3.344	2a-2a 127 c
138	0.649	0.300	0.015	0.016	1.861	0.000	0.501	3.342	2a-2a 128 c
139	0.638	0.299	0.006	0.017	1.872	0.002	0.505	3.339	2a-2a 129 c
140	0.702	0.419	0.001	0.019	1.798	0.000	0.426	3.365	2a-2a 130 c
141	0.716	0.447	0.001	0.018	1.759	0.000	0.417	3.359	2a-2a 131 c
142	0.689	0.403	0.001	0.018	1.817	0.000	0.436	3.362	2a-2a 132 c
143	0.619	0.373	0.004	0.017	1.864	0.000	0.467	3.344	2a-2a 133 c
144	0.644	0.355	0.006	0.016	1.854	0.000	0.472	3.348	2a-2a 134 c
145	0.636	0.300	0.017	0.018	1.870	0.001	0.499	3.342	2a-2a 135 c
146	0.662	0.475	0.002	0.016	1.770	0.000	0.418	3.343	2a-2a 136 c
147	0.651	0.351	0.005	0.018	1.854	0.000	0.471	3.350	2a-2a 137 c
148	0.650	0.331	0.003	0.018	1.858	0.000	0.487	3.346	2a-2a 138 c
149	0.625	0.355	0.007	0.016	1.862	0.001	0.477	3.342	2a-2a 139 c
150	0.616	0.352	0.481	0.018	1.499	0.000	0.309	3.274	2a-2a 140 c
151	0.651	0.276	0.010	0.019	1.870	0.000	0.515	3.342	2a-2a 141 c
152	0.642	0.406	0.000	0.016	1.822	0.000	0.455	3.341	2a-2a 142 c
153	0.601	0.310	0.011	0.016	1.928	0.001	0.486	3.352	2b-5 1 c
154	0.676	0.425	0.001	0.019	1.827	0.000	0.420	3.367	2b-5 2 c
155	0.698	0.557	0.000	0.019	1.751	0.000	0.348	3.373	2b-5 3 c
156	0.682	0.604	0.000	0.024	1.900	0.000	0.245	3.454	2b-5 3 a
157	0.696	0.422	0.002	0.020	1.806	0.000	0.421	3.367	2b-5 4 c
158	0.637	0.369	0.008	0.016	1.871	0.000	0.456	3.356	2b-5 5 c
159	1.743	0.531	0.000	0.007	1.129	0.000	0.163	3.572	2b-5 5 a
160	0.729	0.485	0.001	0.019	1.750	0.001	0.386	3.370	2b-5 6 c
161	0.671	0.447	0.001	0.017	1.818	0.000	0.411	3.365	2b-5 7 c
162	0.679	0.391	0.005	0.018	1.829	0.000	0.439	3.362	2b-5 8 c
163	1.608	0.552	0.000	0.013	1.191	0.001	0.178	3.544	2b-5 8 a
164	0.643	0.320	0.011	0.018	1.895	0.002	0.472	3.360	2b-5 9 c
165	1.032	0.733	0.002	0.025	1.395	0.002	0.220	3.409	2b-5 9 a
166	0.638	0.336	0.010	0.018	1.882	0.000	0.472	3.355	2b-5 10 c

Table Spinel. (continued).

No.	Mg	Al	Cr	Mn	Fe	Nb	Ti	Total	Comment
167	0.669	0.403	0.002	0.020	1.843	0.001	0.429	3.367	2b-5 11 c
168	0.964	0.790	0.001	0.025	1.381	0.003	0.219	3.382	2b-5 11 a
169	1.005	0.584	0.002	0.029	1.618	0.001	0.234	3.472	2b-5 12 a
170	0.685	0.395	0.003	0.021	1.828	0.000	0.435	3.366	2b-5 13 c
171	0.688	0.388	0.003	0.021	1.822	0.001	0.440	3.363	2b-5 14 c
172	0.681	0.370	0.008	0.020	1.830	0.002	0.450	3.359	2b-5 15 c
173	0.659	0.398	0.002	0.019	1.819	0.001	0.450	3.348	2b-5 16 c
174	0.672	0.410	0.002	0.019	1.822	0.001	0.434	3.359	2b-5 17 c
175	0.636	0.334	0.012	0.019	1.879	0.001	0.473	3.353	2b-5 18 c
176	0.673	0.362	0.006	0.019	1.835	0.001	0.458	3.356	2b-5 19 c
177	1.051	0.785	0.001	0.022	1.294	0.003	0.224	3.380	2b-5 19 a
178	0.666	0.387	0.002	0.020	1.834	0.001	0.447	3.357	2b-5 20 c
179	0.695	0.335	0.009	0.022	1.850	0.002	0.456	3.370	2b-5 *21 c
180	0.666	0.337	0.009	0.020	1.858	0.001	0.468	3.358	2b-5 *22 c
181	0.650	0.320	0.013	0.018	1.869	0.002	0.479	3.352	2b-5 23 c
182	0.972	0.792	0.002	0.023	1.358	0.003	0.225	3.374	2b-5 23 a
183	0.662	0.425	0.000	0.015	1.814	0.000	0.436	3.351	2b-5 24 c
184	0.649	0.497	0.001	0.012	1.772	0.000	0.410	3.341	2b-5 25 c
185	0.699	0.415	0.001	0.016	1.814	0.000	0.423	3.368	2b-5 26 c
186	1.036	0.703	0.000	0.021	1.436	0.001	0.226	3.422	2b-5 26 a
187	0.656	0.332	0.025	0.017	1.849	0.000	0.471	3.350	2b-5 27 c
188	0.688	0.380	0.004	0.017	1.822	0.001	0.447	3.359	2b-5 28 c
189	0.716	0.411	0.003	0.020	1.789	0.000	0.427	3.366	2b-5 *29 c
190	0.662	0.372	0.005	0.017	1.839	0.000	0.458	3.353	2b-5 30 c
191	0.675	0.370	0.003	0.015	1.845	0.000	0.452	3.361	2b-5 31 c
192	0.669	0.384	0.003	0.016	1.834	0.000	0.450	3.356	2b-5 33 c
193	0.660	0.375	0.003	0.016	1.846	0.000	0.456	3.355	2b-5 34 c
194	0.687	0.388	0.002	0.018	1.823	0.001	0.443	3.361	2b-5 35 c
195	1.087	0.835	0.000	0.019	1.215	0.002	0.211	3.369	2b-5 35 a
196	0.686	0.389	0.005	0.018	1.805	0.001	0.449	3.352	2b-5 36 c
197	0.642	0.313	0.011	0.017	1.891	0.000	0.482	3.356	2b-5 37 c
198	0.625	0.328	0.009	0.015	1.892	0.001	0.480	3.350	2b-5 38 c
199	0.538	0.355	1.284	0.010	0.823	0.001	0.084	3.095	2b-5 *39 c
200	0.674	0.391	0.002	0.016	1.831	0.000	0.445	3.359	2b-5 40 c
201	0.966	0.760	0.000	0.022	1.434	0.001	0.218	3.401	2b-5 40 a
202	0.662	0.361	0.009	0.019	1.849	0.001	0.457	3.357	2b-5 41 c
203	0.663	0.347	0.006	0.017	1.859	0.000	0.466	3.358	2b-5 42 c
204	0.713	0.430	0.000	0.019	1.787	0.001	0.417	3.367	2b-5 43 c
205	0.708	0.395	0.001	0.017	1.817	0.000	0.433	3.370	2b-5 44 c
206	0.691	0.420	0.000	0.016	1.807	0.001	0.428	3.362	2b-5 45 c
207	0.654	0.383	0.166	0.016	1.729	0.001	0.388	3.336	2b-5 46 c
208	0.689	0.351	0.033	0.019	1.824	0.001	0.444	3.362	2b-5 47 c
209	0.685	0.353	0.025	0.018	1.828	0.002	0.450	3.359	2b-5 48 c
210	0.722	0.463	0.000	0.018	1.775	0.000	0.396	3.373	2b-5 49 c
211	1.005	0.723	0.000	0.025	1.446	0.000	0.220	3.418	2b-5 49 a
212	0.684	0.427	0.000	0.018	1.813	0.001	0.421	3.364	2b-5 50 c
213	0.179	0.032	0.000	0.001	0.180	0.032	1.756	2.180	2b-5 50 a
214	0.689	0.427	0.001	0.017	1.809	0.000	0.422	3.364	2b-5 51 c
215	0.688	0.396	0.000	0.018	1.821	0.000	0.440	3.362	2b-5 52 c
216	0.919	0.910	0.000	0.020	1.277	0.002	0.208	3.335	2b-5 52 a
217	0.653	0.364	0.007	0.015	1.862	0.002	0.455	3.357	2b-5 *53 c
218	0.670	0.373	0.003	0.018	1.848	0.000	0.450	3.362	2b-5 *54 c
219	0.665	0.309	0.069	0.018	1.841	0.000	0.455	3.356	2b-5 *55 c
220	0.650	0.359	0.004	0.017	1.872	0.001	0.457	3.360	2b-5 56 c
221	0.637	0.318	0.011	0.016	1.891	0.001	0.480	3.354	2b-5 57 c

Table Spinel. (continued).

No.	Mg	Al	Cr	Mn	Fe	Nb	Ti	Total	Comment
222	0.692	0.396	0.001	0.020	1.822	0.000	0.436	3.366	2b-5 58 c
223	0.662	0.336	0.010	0.017	1.884	0.000	0.459	3.368	2b-5 59 c
224	0.633	0.331	0.009	0.016	1.906	0.001	0.467	3.362	2b-5 60 c
225	0.647	0.374	0.002	0.017	1.863	0.000	0.455	3.357	2b-5 61 c
226	0.614	0.310	0.248	0.015	1.755	0.001	0.389	3.331	2b-5 62 c
227	0.668	0.409	0.001	0.017	1.844	0.000	0.428	3.367	2b-5 63 c
228	0.925	0.845	0.000	0.022	1.377	0.001	0.204	3.373	2b-5 63 a
229	0.677	0.411	0.001	0.018	1.840	0.000	0.424	3.370	2b-5 64 c
230	0.665	0.412	0.002	0.017	1.857	0.000	0.420	3.373	2b-5 65 c
231	0.635	0.332	0.007	0.016	1.909	0.001	0.465	3.364	2b-5 66 c
232	0.646	0.374	0.004	0.016	1.852	0.001	0.458	3.351	2b-5 67 c
233	0.665	0.365	0.006	0.017	1.856	0.000	0.453	3.362	2b-5 68 c
234	0.668	0.407	0.000	0.017	1.841	0.000	0.432	3.365	2b-5 69 c
235	0.637	0.361	0.007	0.017	1.881	0.000	0.456	3.360	2b-5 70 c
236	0.521	0.346	1.329	0.011	0.810	0.001	0.073	3.089	2b-5 71 c
237	0.672	0.398	0.004	0.018	1.841	0.000	0.432	3.366	2b-5 72 c
238	0.650	0.417	0.000	0.016	1.851	0.000	0.428	3.363	2b-5 74 c
239	0.661	0.399	0.000	0.017	1.857	0.000	0.433	3.368	2b-5 *75 c
240	0.674	0.415	0.000	0.019	1.858	0.001	0.412	3.379	2b-5 76 c
241	0.625	0.323	0.033	0.017	1.893	0.000	0.465	3.357	2b-5 77 c
242	0.639	0.404	0.003	0.016	1.858	0.000	0.439	3.358	2b-5 78 c
243	0.663	0.407	0.000	0.016	1.830	0.001	0.439	3.356	2b-5 79 c
244	0.576	0.355	0.805	0.013	1.263	0.000	0.204	3.216	2b-5 80 c
245	0.671	0.360	0.005	0.017	1.855	0.001	0.454	3.362	2b-5 81 c
246	0.670	0.343	0.006	0.017	1.854	0.001	0.466	3.358	2b-5 81 c
247	0.648	0.371	0.001	0.015	1.858	0.001	0.458	3.354	2b-5 82 c
248	0.675	0.339	0.094	0.017	1.801	0.001	0.428	3.354	2b-5 83 c
249	0.717	0.379	0.218	0.020	1.663	0.001	0.352	3.349	2b-5 84 c
250	0.630	0.295	0.046	0.015	1.892	0.001	0.475	3.353	2b-5 85 c
251	0.707	0.409	0.002	0.019	1.815	0.000	0.421	3.373	2b-5 86 c
252	0.685	0.404	0.001	0.017	1.822	0.001	0.435	3.363	2b-5 87 c
253	1.269	0.681	0.000	0.016	1.290	0.001	0.201	3.458	2b-5 87 a
254	1.001	0.547	0.000	0.026	1.645	0.001	0.252	3.473	2b-5 88 a
255	0.687	0.415	0.001	0.017	1.820	0.001	0.425	3.366	2b-5 88 c
256	0.674	0.327	0.016	0.019	1.853	0.001	0.470	3.358	2b-5 89 c
257	0.680	0.398	0.001	0.018	1.829	0.000	0.437	3.363	2b-5 90 c
258	0.687	0.392	0.005	0.019	1.818	0.001	0.439	3.361	2b-5 91 c
259	0.688	0.444	0.002	0.016	1.796	0.001	0.414	3.362	2b-5 92 c
260	0.669	0.372	0.003	0.017	1.840	0.000	0.456	3.356	2b-5 93 c
261	0.705	0.409	0.001	0.020	1.805	0.000	0.428	3.367	2b-5 94 c
262	0.645	0.299	0.034	0.017	1.878	0.001	0.479	3.353	2b-5 95 c
263	0.656	0.384	0.002	0.018	1.843	0.000	0.451	3.355	2b-5 96 c
264	0.688	0.421	0.001	0.017	1.805	0.000	0.428	3.360	2b-5 97 c
265	0.626	0.322	0.010	0.017	1.892	0.001	0.482	3.351	2b-5 98 c
266	0.625	0.338	0.014	0.017	1.882	0.000	0.474	3.350	2b-5 99 c
267	0.657	0.361	0.008	0.017	1.856	0.000	0.458	3.358	2b-5 100 c
268	0.663	0.394	0.002	0.017	1.840	0.000	0.443	3.359	2b-5 101 c
269	0.680	0.386	0.002	0.018	1.828	0.000	0.446	3.360	2b-5 102 c
270	0.622	0.281	0.014	0.016	1.927	0.000	0.497	3.356	2b-5 103 c
271	0.682	0.400	0.002	0.019	1.841	0.000	0.428	3.371	2b-5 104 c
272	0.647	0.388	0.004	0.017	1.852	0.000	0.449	3.356	2b-5 105 c
273	0.637	0.358	0.007	0.015	1.866	0.000	0.467	3.350	2b-5 105 c
274	0.685	0.416	0.002	0.018	1.818	0.001	0.426	3.365	2b-5 106 c
275	0.630	0.302	0.060	0.017	1.874	0.000	0.467	3.351	2b-5 107 c
276	0.677	0.366	0.009	0.020	1.833	0.000	0.454	3.359	2b-5 109 c

Table Spinel. (continued).

No.	Mg	Al	Cr	Mn	Fe	Nb	Ti	Total	Comment
277	0.636	0.326	0.010	0.017	1.883	0.000	0.479	3.352	2b-5 110 c
278	0.650	0.376	0.002	0.018	1.849	0.000	0.459	3.353	2b-5 111 c
279	0.645	0.387	0.001	0.016	1.851	0.000	0.454	3.353	2b-5 112 c
280	0.635	0.330	0.011	0.017	1.885	0.000	0.476	3.354	2b-5 113 c
281	0.662	0.371	0.001	0.018	1.849	0.000	0.457	3.357	2b-5 114 c
282	0.664	0.333	0.010	0.018	1.868	0.000	0.468	3.361	2b-5 115 c
283	0.652	0.357	0.006	0.016	1.852	0.001	0.467	3.351	2b-5 116c
284	1.214	0.725	0.000	0.017	1.257	0.000	0.213	3.425	2b-5 116a
285	0.657	0.363	0.007	0.017	1.850	0.000	0.461	3.355	2b-5 117c
286	0.701	0.419	0.000	0.020	1.809	0.000	0.421	3.370	2b-5 118c
287	0.664	0.385	0.001	0.016	1.826	0.000	0.458	3.350	2b-5 119c
288	0.709	0.414	0.001	0.020	1.791	0.000	0.430	3.363	2b-5 120c
289	0.669	0.393	0.003	0.017	1.821	0.000	0.450	3.352	2b-5 121c
290	0.658	0.354	0.005	0.017	1.842	0.000	0.471	3.348	2b-5 122c
291	0.696	0.415	0.000	0.019	1.796	0.000	0.433	3.359	2b-5 123c
292	0.649	0.310	0.017	0.017	1.874	0.000	0.485	3.352	2b-5 125c
293	0.676	0.376	0.002	0.019	1.837	0.000	0.451	3.360	2b-5 126c
294	0.632	0.271	0.030	0.018	1.904	0.000	0.498	3.352	2b-5 127c
295	0.655	0.362	0.006	0.018	1.855	0.001	0.460	3.356	2b-5 128c
296	0.639	0.335	0.010	0.016	1.872	0.000	0.479	3.349	2b-5 129c
297	0.647	0.403	0.001	0.017	1.835	0.000	0.448	3.350	2b-5 130c
298	0.667	0.336	0.007	0.020	1.887	0.000	0.455	3.373	2b-5 131c
299	0.678	0.401	0.001	0.018	1.818	0.001	0.442	3.357	2b-5 132c
300	0.683	0.403	0.001	0.019	1.810	0.000	0.441	3.357	2b-5 *133c
301	0.632	0.364	0.008	0.014	1.871	0.000	0.463	3.352	2b-5 *134c
302	0.706	0.414	0.001	0.020	1.787	0.001	0.430	3.360	2b-5 135c
303	0.727	0.286	0.000	0.022	1.822	0.000	0.500	3.357	upper 1 c1
304	0.676	0.204	0.000	0.020	1.898	0.000	0.549	3.349	upper 1 c2
305	0.658	0.177	0.002	0.018	1.922	0.000	0.566	3.344	upper 1 c3
306	0.687	0.185	0.010	0.022	1.889	0.000	0.554	3.348	upper 2 c1
307	0.702	0.204	0.000	0.023	1.894	0.000	0.538	3.360	upper 2 c2
308	0.538	0.192	0.000	0.036	2.610	0.000	0.264	3.639	upper 2 r1
309	0.515	0.173	0.000	0.039	2.772	0.001	0.206	3.706	upper 2 r2
310	0.568	0.250	0.000	0.030	2.471	0.000	0.278	3.597	upper 3 r1
311	0.547	0.234	0.000	0.033	2.648	0.000	0.210	3.673	upper 3 r2
312	0.700	0.238	0.000	0.022	1.886	0.000	0.518	3.364	upper 3 c1
313	0.732	0.250	0.000	0.023	1.860	0.000	0.505	3.370	upper 3 c2
314	0.709	0.240	0.000	0.021	1.871	0.000	0.520	3.361	upper 4 c1
315	0.714	0.247	0.000	0.023	1.862	0.000	0.515	3.361	upper 4 c2
316	0.519	0.205	0.000	0.033	2.669	0.000	0.236	3.662	upper 4 a1
317	0.592	0.301	0.000	0.038	2.507	0.000	0.206	3.643	upper 4 a2
318	0.609	0.266	0.000	0.029	2.259	0.001	0.351	3.515	upper 5 r1
319	0.563	0.193	0.000	0.031	2.443	0.000	0.338	3.566	upper 5 r2
320	0.714	0.207	0.000	0.022	1.867	0.000	0.543	3.353	upper 5 c1
321	0.703	0.214	0.002	0.021	1.887	0.000	0.533	3.360	upper 5 c2
322	0.692	0.203	0.000	0.022	1.893	0.000	0.545	3.354	upper 6 c1
323	0.676	0.184	0.003	0.024	1.909	0.002	0.554	3.351	upper 6 c2
324	0.671	0.189	0.000	0.022	1.946	0.001	0.537	3.367	upper 7 c1
325	0.659	0.188	0.000	0.022	1.929	0.001	0.552	3.352	upper 7 c2
326	0.705	0.228	0.000	0.024	1.882	0.001	0.522	3.362	upper 8 c1
327	0.727	0.257	0.000	0.024	1.850	0.000	0.506	3.365	upper 8 c2
328	0.494	0.156	0.000	0.039	2.802	0.003	0.212	3.706	upper 8 r1
329	0.480	0.147	0.001	0.038	2.813	0.003	0.221	3.702	upper 8 r2
330	0.654	0.198	0.000	0.020	1.926	0.001	0.550	3.349	upper 9 c1
331	0.683	0.202	0.001	0.021	1.910	0.001	0.539	3.357	upper 9 c2

Table Spinel. (continued).

No.	Mg	Al	Cr	Mn	Fe	Nb	Ti	Total	Comment
332	0.696	0.207	0.002	0.023	1.894	0.001	0.535	3.358	upper 10 c1
333	0.679	0.188	0.003	0.022	1.904	0.001	0.553	3.350	upper 10 c2
334	0.725	0.274	0.000	0.024	1.859	0.002	0.489	3.372	upper 11 c1
335	0.691	0.214	0.000	0.022	1.900	0.001	0.533	3.359	upper 11 c2
336	0.400	0.064	0.000	0.073	3.113	0.002	0.156	3.808	upper 11 r1
337	0.684	0.188	0.001	0.022	1.901	0.001	0.553	3.351	upper 12 c1
338	0.672	0.172	0.009	0.020	1.915	0.001	0.560	3.348	upper 12 c2
339	0.703	0.209	0.000	0.027	1.891	0.001	0.532	3.362	upper 13 c1
340	0.713	0.224	0.000	0.023	1.871	0.001	0.527	3.359	upper 13 c2
341	0.723	0.266	0.000	0.022	1.845	0.000	0.505	3.362	upper 14 c1
342	0.715	0.251	0.000	0.023	1.844	0.001	0.520	3.353	upper 14 c2
343	0.678	0.210	0.001	0.021	1.893	0.000	0.546	3.349	upper 15 c1
344	0.657	0.175	0.042	0.021	1.883	0.001	0.556	3.335	upper 15 c2
345	0.666	0.178	0.003	0.019	1.908	0.000	0.568	3.342	upper 16 c1
346	0.685	0.201	0.001	0.022	1.890	0.000	0.551	3.348	upper 16 c2
347	0.709	0.250	0.002	0.024	1.851	0.000	0.519	3.355	upper 17 c 1
348	0.707	0.209	0.034	0.023	1.853	0.001	0.526	3.352	upper 17 c2
349	0.633	0.178	0.012	0.021	1.924	0.000	0.569	3.336	upper 18 c1
350	0.686	0.225	0.001	0.021	1.878	0.002	0.536	3.348	upper 18 c2
351	0.674	0.209	0.000	0.020	1.894	0.000	0.549	3.346	upper 19 c1
352	0.683	0.216	0.000	0.021	1.885	0.000	0.543	3.348	upper 19 c2
353	0.534	0.211	0.002	0.034	2.633	0.001	0.239	3.653	upper 19 a1
354	0.473	0.056	0.000	0.094	3.126	0.006	0.104	3.859	upper 19 a2
355	0.451	0.029	0.001	0.076	3.074	0.002	0.175	3.807	upper 20 a1
356	0.512	0.199	0.001	0.035	2.651	0.002	0.249	3.649	upper 20 a2
357	0.671	0.188	0.003	0.022	1.906	0.000	0.556	3.348	upper 20 c1
358	0.696	0.226	0.001	0.023	1.856	0.001	0.541	3.344	upper 20 c2
359	0.697	0.235	0.001	0.022	1.866	0.000	0.530	3.352	upper 21 c1
360	0.695	0.230	0.000	0.023	1.868	0.000	0.535	3.351	upper 21 c2
361	0.554	0.232	0.001	0.032	2.467	0.000	0.299	3.584	upper 21 a1
362	0.488	0.140	0.001	0.048	2.790	0.001	0.229	3.698	upper 21 a2
363	0.679	0.190	0.000	0.025	1.899	0.000	0.556	3.349	upper 22 c1
364	0.679	0.182	0.001	0.026	1.902	0.000	0.559	3.349	upper 22 c2
365	0.516	0.214	0.001	0.036	2.600	0.000	0.264	3.629	upper 22 r1
366	0.528	0.216	0.000	0.034	2.598	0.000	0.258	3.634	upper 22 r2
367	0.541	0.228	0.000	0.037	2.664	0.001	0.207	3.678	upper 23 r1
368	0.678	0.223	0.001	0.019	1.889	0.000	0.539	3.349	upper 23 c1
369	0.659	0.186	0.000	0.021	1.914	0.000	0.563	3.344	upper 24 c1
370	0.675	0.209	0.000	0.020	1.889	0.000	0.551	3.344	upper 24 c2
371	0.714	0.274	0.001	0.022	1.843	0.000	0.505	3.358	upper 25 c1
372	0.722	0.301	0.000	0.022	1.835	0.001	0.484	3.364	upper 25 c2
373	0.538	0.214	0.001	0.037	2.662	0.000	0.220	3.672	upper 25 r1
374	0.577	0.231	0.000	0.030	2.365	0.001	0.340	3.544	upper 25 r2
375	0.692	0.217	0.001	0.021	1.875	0.001	0.542	3.348	upper 26 c1
376	0.695	0.208	0.000	0.022	1.881	0.000	0.545	3.351	upper 26 c2
377	0.556	0.348	1.243	0.011	0.825	0.000	0.111	3.094	upper 27 c1
378	0.560	0.353	1.243	0.011	0.821	0.000	0.107	3.095	upper 27 c2
379	0.690	0.228	0.001	0.022	1.864	0.001	0.540	3.345	upper 28 c1
380	0.706	0.251	0.000	0.023	1.857	0.001	0.517	3.355	upper 28 c2
381	0.352	0.003	0.002	0.081	3.157	0.001	0.200	3.796	upper 28 r1
382	0.568	0.242	0.000	0.029	2.418	0.002	0.308	3.568	upper 28 r2
383	0.683	0.212	0.000	0.020	1.879	0.001	0.548	3.344	upper 29 c1
384	0.687	0.226	0.001	0.021	1.882	0.001	0.534	3.351	upper 30 c1
385	0.663	0.210	0.001	0.020	1.918	0.002	0.539	3.353	upper 31 c1
386	0.624	0.189	0.145	0.021	1.850	0.001	0.500	3.331	upper 32 c1

Table Spinel. (continued).

No.	Mg	Al	Cr	Mn	Fe	Nb	Ti	Total	Comment
387	0.628	0.182	0.066	0.019	1.912	0.001	0.533	3.341	upper 33 c1
388	0.697	0.189	0.005	0.023	1.876	0.001	0.555	3.347	upper 34 c1
389	0.706	0.204	0.002	0.023	1.883	0.002	0.538	3.357	upper 35 c1
390	0.639	0.189	0.001	0.020	1.927	0.002	0.562	3.340	upper 36 c1
391	0.707	0.256	0.001	0.024	1.859	0.002	0.510	3.358	upper 37 c1
392	0.699	0.252	0.001	0.024	1.876	0.002	0.509	3.362	upper 37 c2
393	0.670	0.192	0.001	0.021	1.902	0.001	0.558	3.344	upper 38 c1
394	0.659	0.181	0.032	0.021	1.904	0.002	0.546	3.345	upper 38 c2
395	0.683	0.191	0.003	0.021	1.912	0.002	0.544	3.356	upper 39 c1
396	0.661	0.189	0.014	0.022	1.912	0.002	0.549	3.347	upper 40 c1
397	0.678	0.195	0.006	0.021	1.895	0.002	0.550	3.347	upper 41 c1
398	0.688	0.200	0.002	0.023	1.904	0.001	0.540	3.358	upper 42 c1
399	0.548	0.233	0.000	0.033	2.536	0.001	0.265	3.616	upper 42 r1
400	0.701	0.201	0.005	0.025	1.878	0.002	0.542	3.353	upper 43 c1
401	0.697	0.245	0.001	0.021	1.869	0.002	0.520	3.354	upper 44 c1
402	0.708	0.294	0.000	0.027	1.884	0.002	0.468	3.382	upper 45 c1
403	0.709	0.234	0.000	0.023	1.890	0.000	0.513	3.370	upper 46 c1
404	0.674	0.210	0.000	0.020	1.927	0.000	0.531	3.363	upper 47 c1
405	0.705	0.219	0.001	0.022	1.903	0.000	0.520	3.370	upper 48 c1
406	0.503	0.201	0.001	0.033	2.670	0.001	0.244	3.653	upper 48 a1
407	0.610	0.293	0.786	0.017	1.276	0.001	0.238	3.221	upper 49 c1
408	0.011	0.003	0.003	0.004	3.961	0.004	0.003	3.988	upper 50 c1
409	0.659	0.186	0.003	0.020	1.949	0.000	0.544	3.361	upper 51 c1
410	0.682	0.188	0.004	0.021	1.918	0.000	0.545	3.359	upper 52 c1
411	0.703	0.238	0.001	0.021	1.896	0.001	0.510	3.370	upper 53 c1
412	0.662	0.182	0.008	0.020	1.947	0.001	0.543	3.362	upper 54 c1
413	0.703	0.285	0.001	0.022	1.896	0.001	0.474	3.382	upper 55 c1
414	0.526	0.209	0.001	0.034	2.620	0.001	0.252	3.642	upper 55 a1
415	0.647	0.182	0.047	0.018	1.926	0.000	0.533	3.353	upper 56 c1
416	0.677	0.196	0.004	0.021	1.937	0.000	0.533	3.367	upper 56 c7
417	0.697	0.199	0.004	0.023	1.912	0.001	0.531	3.367	upper 57 c1
418	0.568	0.244	0.001	0.032	2.458	0.002	0.286	3.590	upper 57 a1
419	0.631	0.177	0.050	0.018	1.953	0.001	0.528	3.357	upper 58 c1
420	0.715	0.369	0.001	0.023	1.877	0.000	0.415	3.400	upper 59 c1
421	0.505	0.209	0.001	0.034	2.672	0.001	0.236	3.658	upper 59 r1
422	0.654	0.180	0.016	0.020	1.945	0.001	0.544	3.358	upper 60 c1
423	0.701	0.272	0.000	0.022	1.854	0.000	0.507	3.357	upper 61 c1
424	0.710	0.291	0.000	0.022	1.854	0.000	0.489	3.366	upper 61 c2
425	0.664	0.191	0.138	0.020	1.829	0.000	0.496	3.339	upper 62 c1
426	0.674	0.176	0.015	0.021	1.896	0.000	0.561	3.343	upper 62 c2
427	0.701	0.328	0.001	0.024	1.944	0.000	0.420	3.416	upper 63 c1
428	0.711	0.253	0.000	0.023	1.851	0.000	0.517	3.356	upper 64 c1
429	0.666	0.195	0.000	0.020	1.902	0.000	0.559	3.343	upper 65 c1
430	0.674	0.208	0.002	0.021	1.934	0.000	0.528	3.367	upper 66 c1

Table K-L Apatite. K-L apatite compositions (wt. %).

No.	SiO2	FeO	MnO	MgO	CaO	SrO	UO2	P2O5	La2O3	Ce2O3	Nd2O3	F	Cl	Total	Comment
62	3.83	0.27	0.00	0.34	53.23	0.45	0.00	32.01	0.27	0.28	0.15	0.65	0.03	91.25	2B 1
63	4.38	0.34	0.02	0.58	51.43	0.49	0.00	31.34	0.26	0.28	0.03	0.62	0.06	89.55	2B 2
64	3.45	0.42	0.00	1.17	51.58	0.52	0.00	31.82	0.17	0.28	0.10	0.80	0.04	89.98	2B 3
65	3.81	0.12	0.02	0.55	52.98	0.52	0.00	32.77	0.07	0.28	0.12	0.73	0.03	91.70	2B 4
66	3.65	0.21	0.02	0.31	53.04	0.43	0.00	33.50	0.22	0.22	0.21	0.75	0.03	92.26	2B 5
67	4.50	0.64	0.03	0.90	51.98	0.46	0.00	32.26	0.16	0.21	0.21	0.79	0.03	91.82	2B 6
68	3.56	0.35	0.05	0.24	55.03	0.42	0.00	33.09	0.19	0.10	0.08	0.76	0.02	93.57	2B 7
69	3.93	0.17	0.03	0.26	54.16	0.45	0.00	32.09	0.23	0.24	0.15	0.63	0.03	92.10	2B 8
70	3.81	0.24	0.04	0.29	54.29	0.48	0.00	32.08	0.14	0.13	0.09	0.55	0.04	91.94	2B 9
71	3.45	0.22	0.04	0.25	54.55	0.44	0.00	33.99	0.22	0.23	0.10	0.77	0.05	93.96	2B 10
72	2.94	0.21	0.04	0.23	54.06	0.42	0.00	34.48	0.16	0.19	0.07	0.79	0.06	93.30	2B 11
73	2.95	0.18	0.05	0.15	54.47	0.50	0.00	34.52	0.12	0.15	0.03	0.71	0.02	93.54	2B 12
74	3.67	0.34	0.04	0.81	52.62	0.51	0.00	32.34	0.13	0.28	0.03	0.69	0.08	91.21	2B 13
75	3.69	0.54	0.04	0.42	53.74	0.48	0.00	33.12	0.20	0.28	0.12	0.76	0.03	93.09	2B 14
76	3.54	0.23	0.04	0.27	54.05	0.43	0.00	32.40	0.12	0.10	0.10	0.64	0.04	91.67	2B 15
77	3.61	0.17	0.05	0.25	54.18	0.47	0.00	32.39	0.07	0.29	0.13	0.61	0.04	92.00	2B 16 s
78	3.50	0.22	0.05	0.29	53.76	0.37	0.00	32.97	0.18	0.21	0.09	0.71	0.03	92.06	2B 17
79	4.53	0.47	0.03	0.92	52.51	0.44	0.00	32.41	0.12	0.27	0.05	0.80	0.04	92.24	2B 18
80	3.54	0.30	0.07	0.79	53.54	0.36	0.00	32.80	0.11	0.20	0.08	0.69	0.04	92.22	2B 19
81	3.52	0.49	0.05	0.98	52.79	0.36	0.00	31.23	0.18	0.28	0.07	0.73	0.04	90.41	2B 20
82	3.83	0.24	0.02	0.31	53.93	0.38	0.00	31.70	0.21	0.17	0.04	0.54	0.07	91.19	2B 21 s
83	3.79	0.23	0.07	0.25	53.84	0.42	0.00	31.44	0.21	0.09	0.02	0.60	0.05	90.74	2B 21 s
84	3.69	0.26	0.05	0.32	53.86	0.44	0.00	32.10	0.23	0.22	0.05	0.57	0.06	91.59	2B 21 s
85	3.54	0.23	0.03	0.25	54.10	0.48	0.00	32.63	0.19	0.19	0.00	0.61	0.03	92.00	2B 21 s
86	3.54	0.16	0.04	0.24	54.42	0.48	0.00	32.33	0.18	0.18	0.06	0.68	0.03	92.04	2B 22
87	3.38	0.21	0.01	0.36	53.80	0.44	0.00	33.48	0.14	0.09	0.10	0.66	0.04	92.40	2B 23
88	4.06	0.16	0.04	0.35	53.71	0.51	0.00	31.02	0.17	0.42	0.05	0.55	0.04	90.83	2B 24
89	4.30	0.61	0.07	1.32	51.57	0.44	0.00	31.02	0.24	0.23	0.09	0.89	0.05	90.43	2B 25
90	4.44	0.39	0.04	0.91	52.77	0.52	0.00	31.64	0.19	0.44	0.13	0.75	0.03	91.92	2B 26 s
91	3.81	0.25	0.03	0.44	53.96	0.47	0.00	32.05	0.16	0.27	0.09	0.67	0.03	91.92	2B 26 s
92	4.16	0.30	0.05	0.42	53.18	0.57	0.00	31.08	0.19	0.24	0.08	0.65	0.01	90.64	2B 27

Table K-L Apatite. (continued).

No.	SiO2	FeO	MnO	MgO	CaO	SrO	UO2	P2O5	La2O3	Ce2O3	Nd2O3	F	Cl	Total	Comment
93	4.03	0.22	0.04	0.32	53.69	0.53	0.00	31.60	0.12	0.29	0.00	0.72	0.04	91.29	2B 28 s
94	3.74	0.15	0.04	0.28	53.80	0.50	0.00	32.34	0.13	0.27	0.08	0.67	0.03	91.75	2B 29 s
95	3.88	0.14	0.03	0.31	54.29	0.47	0.00	32.13	0.15	0.31	0.03	0.66	0.03	92.15	2B 30 s
96	3.51	0.13	0.03	0.25	54.72	0.55	0.00	33.45	0.12	0.38	0.03	0.75	0.05	93.62	2B 31
97	4.10	0.22	0.04	0.46	53.65	0.55	0.00	31.71	0.23	0.27	0.09	0.71	0.01	91.74	2B 32
98	3.81	0.16	0.05	0.37	54.03	0.58	0.00	31.81	0.12	0.12	0.03	0.68	0.03	91.48	2B 33
99	2.95	0.11	0.03	0.21	54.57	0.48	0.00	34.61	0.17	0.27	0.06	0.74	0.01	93.89	2B 34
100	3.32	0.09	0.02	0.37	54.56	0.50	0.00	33.49	0.21	0.21	0.01	0.73	0.02	93.19	2B 35
101	3.61	0.12	0.04	0.27	54.00	0.53	0.00	32.10	0.14	0.19	0.07	0.68	0.03	91.48	2B 36
102	3.86	0.14	0.03	0.36	54.15	0.49	0.00	32.16	0.10	0.24	0.08	0.73	0.05	92.06	2B 37
103	3.44	0.15	0.01	0.24	53.72	0.51	0.00	33.47	0.20	0.26	0.09	0.57	0.03	92.45	2B 38 s
104	3.68	0.11	0.01	0.35	54.25	0.52	0.00	33.06	0.10	0.23	0.06	0.68	0.04	92.78	2B 39
105	3.55	0.11	0.02	0.34	53.32	0.51	0.00	33.78	0.19	0.15	0.10	0.66	0.03	92.47	2B 40
106	2.96	0.02	0.04	0.20	54.32	0.48	0.00	34.05	0.12	0.15	0.08	0.86	0.01	92.92	2B 41
107	3.77	0.09	0.01	0.32	53.20	0.59	0.00	30.73	0.11	0.18	0.06	0.66	0.04	89.46	2B 42
108	2.85	0.08	0.01	0.22	54.13	0.44	0.00	33.80	0.27	0.23	0.04	0.78	0.03	92.54	2B 43 s
109	2.65	0.08	0.00	0.16	53.87	0.52	0.00	34.80	0.23	0.27	0.04	0.79	0.03	93.11	2B 43 s
110	2.83	0.09	0.00	0.15	54.18	0.50	0.00	34.37	0.20	0.28	0.05	0.72	0.04	93.10	2B 43 s
111	3.67	0.09	0.02	0.26	54.06	0.49	0.00	33.00	0.25	0.29	0.00	0.59	0.04	92.50	2B 44
112	3.20	0.11	0.02	0.22	54.41	0.53	0.00	33.69	0.20	0.36	0.09	0.69	0.05	93.25	2B 45
113	4.10	0.18	0.01	0.63	53.36	0.55	0.00	31.88	0.26	0.38	0.00	0.73	0.06	91.82	2B 46
114	3.11	0.09	0.03	0.25	54.21	0.44	0.00	32.59	0.21	0.37	0.00	0.81	0.04	91.78	2B 47
115	3.49	0.10	0.01	0.50	54.16	0.47	0.00	32.90	0.24	0.34	0.04	0.70	0.05	92.69	2B 48
116	2.68	0.13	0.03	0.26	53.61	0.59	0.00	34.32	0.20	0.21	0.00	0.90	0.05	92.59	2B 49
117	2.87	0.08	0.02	0.18	54.15	0.54	0.00	33.41	0.20	0.21	0.00	0.77	0.03	92.11	2B 50
118	4.02	0.08	0.01	0.35	54.00	0.47	0.00	30.94	0.24	0.31	0.00	0.63	0.05	90.83	2B 51
119	2.85	0.07	0.01	0.18	54.27	0.44	0.00	34.03	0.16	0.35	0.07	0.74	0.04	92.86	2B 52
120	3.61	0.18	0.00	0.27	54.07	0.45	0.00	32.56	0.29	0.29	0.04	0.63	0.04	92.16	2B 53
121	3.48	0.17	0.01	0.25	54.25	0.48	0.00	32.38	0.19	0.38	0.06	0.72	0.05	92.12	2B 54
122	2.83	0.27	0.01	0.16	53.71	0.58	0.00	34.45	0.22	0.28	0.00	0.81	0.04	93.00	2B 55 s
123	2.67	0.34	0.02	0.16	54.04	0.57	0.00	34.81	0.16	0.19	0.00	0.74	0.03	93.40	2B 55 s
124	3.07	0.30	0.00	0.21	54.29	0.54	0.00	33.81	0.34	0.35	0.09	0.74	0.04	93.45	2B 56

Table K-L Apatite. (continued).

No.	SiO2	FeO	MnO	MgO	CaO	SrO	UO2	P2O5	La2O3	Ce2O3	Nd2O3	F	Cl	Total	Comment
125	3.40	0.17	0.01	0.27	54.09	0.51	0.00	32.33	0.16	0.25	0.00	0.68	0.06	91.64	2B 57
126	3.67	0.11	0.00	0.31	53.52	0.55	0.00	31.00	0.25	0.30	0.00	0.56	0.04	90.06	2B 58
127	3.77	0.12	0.02	0.32	53.39	0.58	0.00	30.93	0.21	0.26	0.00	0.61	0.06	89.99	2B 59
128	3.74	0.44	0.04	0.81	53.91	0.49	0.00	33.39	0.23	0.39	0.17	0.83	0.03	94.11	2B 60
129	3.71	0.11	0.04	0.28	54.14	0.61	0.00	32.15	0.14	0.28	0.09	0.66	0.04	91.96	2B 61
130	3.46	0.27	0.04	0.34	54.15	0.51	0.00	33.15	0.16	0.37	0.14	0.65	0.05	93.02	2B 62
131	3.75	0.15	0.03	0.31	55.41	0.52	0.00	32.61	0.17	0.29	0.11	1.02	0.03	93.96	2B 63
132	3.22	0.11	0.04	0.26	54.25	0.42	0.00	33.64	0.23	0.32	0.11	0.70	0.03	93.02	2B 64 s
133	3.84	0.13	0.03	0.26	53.57	0.53	0.00	31.97	0.12	0.44	0.07	0.66	0.02	91.36	2B 64 s
134	3.94	0.14	0.04	0.28	53.92	0.64	0.00	31.01	0.07	0.27	0.11	0.60	0.05	90.80	2B 65

Table K-L Apatite. Structural formula based on 25 oxygens.

No.	Si	Fe	Mn	Mg	Ca	Sr	U	P	La	Ce	Nd	F	Cl	Total	Comment
62	0.716	0.042	0.000	0.096	10.654	0.049	0.000	5.062	0.019	0.019	0.010	0.386	0.010	17.063	2B 1
63	0.829	0.055	0.004	0.162	10.440	0.054	0.000	5.027	0.018	0.020	0.002	0.370	0.018	16.999	2B 2
64	0.652	0.067	0.000	0.331	10.451	0.057	0.000	5.094	0.012	0.019	0.007	0.477	0.012	17.176	2B 3
65	0.703	0.019	0.003	0.153	10.494	0.056	0.000	5.128	0.005	0.019	0.008	0.429	0.010	17.027	2B 4
66	0.669	0.031	0.003	0.084	10.425	0.045	0.000	5.203	0.015	0.015	0.014	0.434	0.010	16.948	2B 5
67	0.830	0.098	0.005	0.248	10.280	0.049	0.000	5.041	0.011	0.015	0.014	0.460	0.008	17.057	2B 6
68	0.649	0.054	0.008	0.065	10.738	0.044	0.000	5.103	0.013	0.007	0.005	0.440	0.006	17.131	2B 7
69	0.727	0.026	0.005	0.073	10.749	0.048	0.000	5.033	0.016	0.017	0.010	0.369	0.010	17.082	2B 8
70	0.707	0.037	0.006	0.080	10.785	0.052	0.000	5.036	0.009	0.009	0.006	0.325	0.014	17.066	2B 9
71	0.623	0.033	0.006	0.067	10.555	0.047	0.000	5.197	0.015	0.015	0.006	0.441	0.014	17.018	2B 10
72	0.534	0.032	0.007	0.061	10.508	0.044	0.000	5.296	0.011	0.013	0.004	0.450	0.018	16.977	2B 11
73	0.534	0.027	0.008	0.039	10.558	0.053	0.000	5.287	0.008	0.010	0.002	0.405	0.007	16.938	2B 12
74	0.683	0.053	0.006	0.224	10.501	0.055	0.000	5.101	0.009	0.019	0.002	0.404	0.024	17.079	2B 13
75	0.674	0.082	0.006	0.116	10.524	0.051	0.000	5.125	0.014	0.019	0.008	0.438	0.009	17.065	2B 14
76	0.658	0.035	0.006	0.075	10.754	0.046	0.000	5.094	0.008	0.007	0.007	0.374	0.012	17.076	2B 15
77	0.669	0.027	0.008	0.069	10.756	0.051	0.000	5.081	0.004	0.020	0.009	0.359	0.012	17.064	2B 16 s
78	0.645	0.034	0.007	0.078	10.628	0.039	0.000	5.150	0.012	0.014	0.006	0.416	0.011	17.041	2B 17
79	0.831	0.072	0.005	0.252	10.327	0.047	0.000	5.037	0.008	0.018	0.003	0.464	0.013	17.078	2B 18
80	0.652	0.046	0.011	0.217	10.562	0.038	0.000	5.113	0.007	0.014	0.006	0.400	0.013	17.079	2B 19
81	0.667	0.078	0.009	0.277	10.702	0.040	0.000	5.003	0.013	0.019	0.005	0.439	0.012	17.262	2B 20
82	0.717	0.038	0.003	0.086	10.807	0.041	0.000	5.020	0.014	0.012	0.003	0.319	0.021	17.081	2B 21 s
83	0.712	0.036	0.010	0.070	10.855	0.046	0.000	5.010	0.015	0.006	0.002	0.359	0.017	17.138	2B 21 s
84	0.687	0.040	0.008	0.089	10.743	0.047	0.000	5.059	0.015	0.015	0.003	0.335	0.019	17.062	2B 21 s
85	0.654	0.036	0.005	0.068	10.721	0.051	0.000	5.109	0.013	0.013	0.000	0.355	0.009	17.033	2B 21 s
86	0.655	0.025	0.006	0.065	10.810	0.051	0.000	5.076	0.012	0.012	0.004	0.399	0.010	17.127	2B 22
87	0.619	0.032	0.001	0.098	10.564	0.046	0.000	5.195	0.010	0.006	0.007	0.381	0.012	16.971	2B 23
88	0.766	0.026	0.006	0.098	10.845	0.056	0.000	4.950	0.012	0.029	0.003	0.327	0.014	17.130	2B 24
89	0.811	0.096	0.012	0.372	10.416	0.048	0.000	4.951	0.017	0.016	0.006	0.528	0.014	17.285	2B 25
90	0.824	0.061	0.007	0.252	10.482	0.055	0.000	4.967	0.013	0.030	0.008	0.441	0.008	17.148	2B 26 s
91	0.707	0.038	0.005	0.121	10.730	0.051	0.000	5.036	0.011	0.018	0.006	0.392	0.009	17.123	2B 26 s
92	0.784	0.047	0.008	0.118	10.743	0.062	0.000	4.961	0.013	0.016	0.006	0.385	0.005	17.147	2B 27

Table K-L Apatite. (continued).

No.	Si	Fe	Mn	Mg	Ca	Sr	U	P	La	Ce	Nd	F	Cl	Total	Comment
93	0.753	0.034	0.007	0.088	10.757	0.058	0.000	5.003	0.008	0.020	0.000	0.425	0.014	17.167	2B 28 s
94	0.694	0.024	0.007	0.078	10.699	0.054	0.000	5.081	0.009	0.019	0.005	0.395	0.008	17.071	2B 29 s
95	0.718	0.021	0.004	0.087	10.766	0.050	0.000	5.035	0.010	0.021	0.002	0.387	0.009	17.110	2B 30 s
96	0.637	0.020	0.005	0.068	10.656	0.058	0.000	5.147	0.008	0.025	0.002	0.429	0.014	17.067	2B 31
97	0.763	0.034	0.007	0.127	10.698	0.060	0.000	4.996	0.016	0.019	0.006	0.417	0.003	17.144	2B 32
98	0.710	0.025	0.008	0.102	10.798	0.062	0.000	5.023	0.008	0.008	0.002	0.401	0.010	17.157	2B 33
99	0.531	0.017	0.004	0.055	10.547	0.051	0.000	5.286	0.011	0.018	0.004	0.419	0.003	16.946	2B 34
100	0.604	0.013	0.003	0.100	10.657	0.053	0.000	5.169	0.014	0.014	0.000	0.418	0.006	17.052	2B 35
101	0.674	0.019	0.007	0.074	10.787	0.057	0.000	5.067	0.009	0.013	0.005	0.403	0.009	17.125	2B 36
102	0.715	0.022	0.005	0.098	10.745	0.053	0.000	5.043	0.007	0.016	0.006	0.425	0.016	17.149	2B 37
103	0.630	0.023	0.001	0.066	10.552	0.054	0.000	5.195	0.014	0.018	0.006	0.330	0.009	16.897	2B 38 s
104	0.673	0.017	0.002	0.096	10.640	0.055	0.000	5.123	0.007	0.016	0.004	0.393	0.014	17.036	2B 39
105	0.649	0.017	0.003	0.092	10.435	0.054	0.000	5.223	0.013	0.010	0.006	0.382	0.008	16.892	2B 40
106	0.540	0.004	0.006	0.053	10.620	0.051	0.000	5.261	0.008	0.010	0.005	0.497	0.003	17.057	2B 41
107	0.722	0.014	0.001	0.092	10.905	0.065	0.000	4.977	0.008	0.012	0.004	0.401	0.012	17.213	2B 42
108	0.524	0.012	0.002	0.061	10.645	0.047	0.000	5.253	0.018	0.016	0.002	0.452	0.008	17.039	2B 43 s
109	0.482	0.012	0.001	0.044	10.488	0.055	0.000	5.353	0.016	0.018	0.003	0.455	0.008	16.933	2B 43 s
110	0.516	0.014	0.000	0.039	10.567	0.053	0.000	5.297	0.014	0.019	0.003	0.415	0.011	16.946	2B 43 s
111	0.674	0.013	0.003	0.072	10.635	0.052	0.000	5.129	0.017	0.020	0.000	0.344	0.013	16.972	2B 44
112	0.583	0.016	0.003	0.061	10.629	0.057	0.000	5.202	0.013	0.024	0.006	0.399	0.015	17.007	2B 45
113	0.762	0.028	0.001	0.174	10.617	0.059	0.000	5.013	0.018	0.026	0.000	0.429	0.020	17.146	2B 46
114	0.578	0.013	0.004	0.070	10.811	0.048	0.000	5.135	0.015	0.025	0.000	0.474	0.012	17.185	2B 47
115	0.640	0.015	0.002	0.136	10.660	0.050	0.000	5.118	0.016	0.023	0.003	0.408	0.017	17.087	2B 48
116	0.491	0.019	0.005	0.072	10.518	0.062	0.000	5.321	0.013	0.014	0.000	0.519	0.016	17.051	2B 49
117	0.530	0.012	0.003	0.049	10.715	0.058	0.000	5.225	0.014	0.014	0.000	0.450	0.008	17.077	2B 50
118	0.758	0.013	0.002	0.099	10.912	0.052	0.000	4.940	0.016	0.021	0.000	0.378	0.016	17.208	2B 51
119	0.521	0.010	0.001	0.048	10.629	0.046	0.000	5.266	0.011	0.023	0.004	0.427	0.012	16.999	2B 52
120	0.667	0.027	0.000	0.075	10.710	0.049	0.000	5.097	0.020	0.020	0.003	0.368	0.012	17.047	2B 53
121	0.646	0.027	0.002	0.070	10.781	0.052	0.000	5.085	0.013	0.026	0.004	0.420	0.015	17.141	2B 54
122	0.516	0.042	0.001	0.044	10.486	0.061	0.000	5.314	0.015	0.019	0.000	0.465	0.011	16.973	2B 55 s
123	0.484	0.051	0.003	0.042	10.493	0.060	0.000	5.340	0.011	0.012	0.000	0.425	0.010	16.930	2B 55 s

Table K-L Apatite. (continued).

No.	Si	Fe	Mn	Mg	Ca	Sr	U	P	La	Ce	Nd	F	Cl	Total	Comment
124	0.560	0.046	0.000	0.057	10.602	0.057	0.000	5.217	0.023	0.023	0.006	0.425	0.013	17.027	2B 56
125	0.633	0.027	0.002	0.076	10.790	0.055	0.000	5.097	0.011	0.017	0.000	0.399	0.018	17.124	2B 57
126	0.698	0.017	0.000	0.087	10.905	0.060	0.000	4.991	0.018	0.021	0.000	0.337	0.012	17.145	2B 58
127	0.718	0.020	0.003	0.091	10.883	0.063	0.000	4.982	0.015	0.018	0.000	0.366	0.018	17.177	2B 59
128	0.677	0.067	0.006	0.217	10.447	0.051	0.000	5.112	0.015	0.026	0.011	0.473	0.008	17.110	2B 60
129	0.688	0.018	0.006	0.077	10.771	0.065	0.000	5.054	0.010	0.019	0.006	0.386	0.014	17.113	2B 61
130	0.634	0.041	0.006	0.094	10.622	0.055	0.000	5.139	0.011	0.025	0.009	0.379	0.015	17.029	2B 62
131	0.684	0.022	0.004	0.083	10.824	0.055	0.000	5.034	0.012	0.020	0.007	0.586	0.009	17.341	2B 63
132	0.588	0.016	0.005	0.069	10.617	0.045	0.000	5.202	0.016	0.022	0.007	0.406	0.010	17.003	2B 64 s
133	0.716	0.020	0.005	0.072	10.716	0.058	0.000	5.053	0.008	0.030	0.005	0.392	0.007	17.082	2B 64 s
134	0.743	0.022	0.006	0.079	10.903	0.071	0.000	4.955	0.005	0.019	0.007	0.356	0.015	17.179	2B 65

Table Aya Apatite. Aya apatite compositions (wt. %).

No.	SiO2	FeO	MnO	MgO	CaO	Na2O	SO3	P2O5	La2O3	Ce2O3	Pr2O3	Nd2O3	F	Cl	Total	Comment
3	0.56	0.62	0.05	0.06	53.73	0.07	0.69	39.94	0.16	0.23	0.05	0.22	3.09	0.08	98.23	5j circle 1 apatite 1
4	0.76	0.69	0.03	0.03	50.78	0.06	0.42	39.85	0.22	0.35	0.09	0.32	2.86	0.09	95.33	5j circle 1 apatite 2
5	0.00	0.28	0.02	0.02	53.95	0.00	0.00	41.30	0.11	0.00	0.00	0.00	3.09	0.02	97.47	5j circle 1 apatite 3
6	0.94	0.54	0.02	0.09	52.38	0.07	0.70	39.31	0.29	0.53	0.05	0.22	2.87	0.08	96.84	5j circle 1 apatite 4
8	0.99	0.86	0.05	0.11	51.76	0.08	0.87	39.10	0.12	0.24	0.04	0.29	2.66	0.07	96.08	5j circle 1 apatite 6
9	0.20	0.40	0.05	0.02	52.25	0.00	0.10	40.37	0.21	0.34	0.07	0.26	2.76	0.04	95.89	5j circle 1 apatite 7
10	0.00	0.25	0.03	0.03	53.01	0.00	0.07	41.46	0.08	0.00	0.00	0.04	2.47	0.02	96.40	5j circle 2 apatite 1
11	0.00	0.24	0.02	0.01	53.16	0.00	0.00	41.41	0.04	0.00	0.01	0.06	2.48	0.03	96.41	5j circle 2 apatite 2
12	0.00	0.17	0.00	0.00	53.45	0.01	0.03	41.41	0.01	0.00	0.00	0.00	2.86	0.03	96.76	5j circle 2 apatite 3
13	0.00	0.24	0.01	0.03	52.90	0.02	0.29	39.63	0.06	0.00	0.02	0.12	2.75	0.05	94.94	5j circle 2 apatite 4
14	0.00	0.19	0.01	0.02	53.74	0.01	0.00	41.76	0.03	0.00	0.00	0.00	2.86	0.05	97.45	5j circle 2 apatite 5
15	0.64	0.42	0.02	0.14	52.26	0.09	0.75	39.54	0.13	0.27	0.00	0.14	3.10	0.06	96.24	5j circle 3 apatite 1
16	1.18	0.61	0.01	0.20	50.85	0.11	0.82	38.17	0.24	0.37	0.07	0.26	3.07	0.05	94.70	5j circle 3 apatite 2
17	0.46	0.46	0.02	0.03	52.45	0.07	0.71	40.36	0.17	0.21	0.03	0.14	2.65	0.07	96.69	5j circle 3 apatite 3
18	0.54	0.83	0.04	0.12	52.24	0.04	0.99	39.85	0.10	0.20	0.00	0.19	2.73	0.05	96.73	5j circle 3 apatite 4
19	0.45	0.52	0.03	0.07	52.99	0.03	0.62	39.54	0.13	0.10	0.03	0.20	2.66	0.04	96.27	5j circle 3 apatite 5
20	0.68	0.55	0.02	0.10	52.31	0.11	0.73	39.39	0.25	0.32	0.00	0.28	3.01	0.05	96.51	5j circle 4 apatite 1
21	0.65	0.59	0.04	0.07	52.93	0.08	0.82	39.58	0.07	0.09	0.00	0.18	2.70	0.05	96.68	5j circle 4 apatite 2
22	0.86	0.71	0.02	0.15	51.75	0.09	1.02	39.59	0.18	0.27	0.10	0.20	2.75	0.03	96.55	5j circle 4 apatite 3
23	0.99	0.37	0.03	0.22	52.80	0.15	0.77	39.84	0.22	0.54	0.02	0.23	3.12	0.11	98.08	5j circle 4 apatite 4
24	0.51	0.39	0.00	0.10	52.84	0.10	0.59	39.69	0.07	0.22	0.06	0.14	2.94	0.06	96.47	5j circle 4 apatite 5
25	0.00	0.18	0.00	0.04	52.98	0.05	0.29	39.83	0.03	0.24	0.00	0.09	3.09	0.03	95.53	5ia circle 1 apatite 1
26	0.55	0.42	0.00	0.08	51.81	0.15	0.76	38.77	0.27	0.58	0.05	0.28	3.20	0.07	95.60	5ia circle 1 apatite 2
27	0.00	0.22	0.02	0.03	53.51	0.04	0.09	40.41	0.09	0.15	0.01	0.13	3.07	0.03	96.51	5ia circle 1 apatite 3
28	0.27	0.26	0.01	0.04	52.99	0.11	0.61	39.62	0.16	0.43	0.03	0.32	2.79	0.05	96.50	5ia circle 2 apatite 1
29	0.56	0.21	0.00	0.03	52.18	0.06	0.40	40.67	0.10	0.18	0.04	0.15	2.66	0.03	96.13	5ia circle 2 apatite 2
30	0.00	0.08	0.00	0.02	53.36	0.00	0.04	41.32	0.02	0.10	0.00	0.02	2.84	0.03	96.63	5ia circle 2 apatite 3
31	0.35	0.26	0.01	0.09	51.28	0.15	0.64	40.06	0.26	0.42	0.06	0.34	2.77	0.07	95.58	5ia circle 3 apatite 1
32	0.68	0.61	0.02	0.20	50.57	0.17	0.91	39.29	0.33	0.64	0.03	0.37	3.25	0.09	95.74	5ia circle 3 apatite 2
33	0.00	0.17	0.02	0.02	53.19	0.06	0.36	40.39	0.10	0.20	0.01	0.12	2.74	0.05	96.25	5ia circle 3 apatite 3
34	0.00	0.15	0.01	0.03	52.91	0.01	0.05	39.92	0.00	0.14	0.00	0.00	3.07	0.04	95.01	5ia circle 4 apatite 1
35	0.00	0.11	0.00	0.02	53.25	0.04	0.06	41.21	0.00	0.13	0.04	0.00	3.07	0.04	96.66	5ia circle 4 apatite 2
36	0.70	0.42	0.02	0.08	51.60	0.15	0.78	39.13	0.22	0.66	0.06	0.37	3.02	0.07	95.97	5ia circle 4 apatite 3
37	0.00	0.10	0.00	0.03	52.39	0.03	0.09	40.59	0.06	0.22	0.06	0.04	2.65	0.04	95.18	5ia circle 5 apatite 1
38	0.00	0.20	0.00	0.03	52.94	0.06	0.37	40.49	0.07	0.19	0.04	0.12	2.53	0.02	96.00	5ia circle 5 apatite 2
39	0.00	0.13	0.00	0.04	54.02	0.02	0.00	42.14	0.06	0.14	0.00	0.00	3.08	0.04	98.35	5ia circle 5 apatite 3

Table Aya Apatite. (continued).

No.	SiO2	FeO	MnO	MgO	CaO	SrO	UO2	P2O5	La2O3	Ce2O3	Nd2O3	F	Cl	Total	Comment	
40	0.07	0.16	0.03	0.03	52.88	0.12	0.42	40.47	0.02	0.19	0.06	0.31	2.85	0.04	96.44	5ia circle 6 apatite 1
41	0.00	0.14	0.01	0.02	52.94	0.11	0.27	40.31	0.10	0.37	0.04	0.23	2.76	0.05	96.17	5ia circle 6 apatite 2
42	0.10	0.12	0.02	0.03	53.10	0.11	0.44	40.15	0.18	0.48	0.09	0.23	3.01	0.05	96.83	5ia circle 6 apatite 3
43	0.00	0.26	0.02	0.00	53.68	0.03	0.22	40.04	0.02	0.07	0.03	0.08	2.98	0.03	96.19	5ib circle 1 apatite 1
44	0.87	1.09	0.02	0.11	51.42	0.14	1.38	38.15	0.28	0.59	0.14	0.21	2.59	0.09	95.96	5ib circle 1 apatite 2
45	0.60	0.64	0.02	0.00	51.92	0.12	0.85	39.31	0.23	0.44	0.02	0.29	2.66	0.08	96.04	5ib circle 1 apatite 3
46	0.89	0.58	0.01	0.23	52.51	0.13	0.78	39.23	0.19	0.35	0.07	0.30	2.54	0.05	96.78	5ib circle 1 apatite 4
47	0.56	0.44	0.04	0.05	53.15	0.12	0.79	39.55	0.25	0.44	0.06	0.21	2.91	0.10	97.44	5ib circle 1 apatite 5
48	0.51	0.50	0.03	0.01	53.63	0.12	0.70	39.38	0.18	0.36	0.10	0.32	2.89	0.05	97.56	5ib circle 2 apatite 1
49	0.00	0.29	0.02	0.00	54.70	0.01	0.03	41.45	0.04	0.00	0.00	0.02	3.05	0.02	98.35	5ib circle 2 apatite 2
50	0.00	0.30	0.02	0.00	54.16	0.00	0.07	40.66	0.05	0.02	0.01	0.06	2.59	0.02	96.87	5ib circle 2 apatite 4
51	0.00	0.26	0.01	0.00	0.00	0.00	0.04	0.00	0.24	0.50	0.03	0.09	0.00	0.00	1.17	5ib circle 2 apatite 5
52	0.14	0.40	0.01	0.00	53.49	0.06	0.57	40.03	0.07	0.15	0.05	0.17	2.80	0.02	96.78	5ib circle 3 apatite 1
53	0.66	0.36	0.03	0.03	51.81	0.15	0.75	38.74	0.26	0.53	0.03	0.25	3.19	0.08	95.50	5ib circle 3 apatite 2
54	0.00	0.17	0.01	0.00	53.85	0.03	0.23	40.06	0.07	0.08	0.00	0.06	2.65	0.02	96.12	5ib circle 3 apatite 3
55	0.24	0.36	0.02	0.00	53.81	0.09	0.57	39.84	0.03	0.19	0.01	0.31	3.03	0.06	97.25	5ib circle 3 apatite 4
56	0.00	0.26	0.03	0.00	54.22	0.01	0.22	40.42	0.02	0.03	0.00	0.11	2.47	0.03	96.78	5ib circle 3 apatite 5
57	0.34	0.36	0.00	0.00	53.62	0.08	0.60	39.35	0.12	0.21	0.03	0.26	3.08	0.02	96.75	5ib circle 4 apatite 1
58	0.00	0.17	0.02	0.00	54.95	0.00	0.05	40.75	0.00	0.03	0.00	0.02	3.09	0.01	97.79	5ib circle 4 apatite 2
59	0.00	0.10	0.02	0.00	54.61	0.01	0.04	41.62	0.02	0.02	0.00	0.05	2.73	0.02	98.08	5ib circle 4 apatite 3
60	0.00	0.23	0.03	0.04	53.44	0.01	0.13	39.37	0.11	0.00	0.00	0.07	3.16	0.00	95.26	5ib circle 4 apatite 4
61	0.00	0.14	0.01	0.00	54.57	0.00	0.02	41.35	0.02	0.00	0.02	0.07	3.01	0.01	97.95	5ib circle 4 apatite 5

Table Aya Apatite. (continued).

No.	SiO2	FeO	MnO	MgO	CaO	SrO	UO2	P2O5	La2O3	Ce2O3	Nd2O3	F	Cl	Total	Comment
135	0.94	0.39	0.06	0.11	54.06	1.88	0.00	40.48	0.17	0.45	0.37	2.94	0.10	100.68	5iA ap 1
136	0.62	0.19	0.06	0.04	54.41	1.41	0.00	41.16	0.16	0.32	0.32	3.24	0.03	100.57	5iA ap 2
137	0.75	0.50	0.05	0.01	53.08	1.33	0.00	41.03	0.07	0.45	0.31	3.04	0.07	99.38	5iA ap 3
138	0.93	0.22	0.07	0.03	53.23	1.56	0.00	40.39	0.20	0.68	0.49	2.99	0.04	99.55	5iA ap 4
139	1.13	0.34	0.03	0.14	52.29	1.51	0.00	40.28	0.20	0.67	0.35	2.73	0.10	98.59	5iA ap 5
140	0.76	0.30	0.04	0.04	53.06	1.35	0.00	41.03	0.04	0.49	0.36	3.00	0.05	99.23	5iA ap 6 side 1
141	0.91	0.45	0.06	0.09	52.47	1.55	0.00	40.58	0.16	0.54	0.35	3.03	0.06	98.94	5iA ap 6 side 2
142	1.09	0.80	0.04	0.15	53.67	1.28	0.00	39.38	0.07	0.31	0.34	3.48	0.07	99.21	5iA ap 7
143	0.45	0.20	0.06	0.01	54.25	1.30	0.00	41.18	0.00	0.22	0.12	3.31	0.04	99.73	5iA ap 8
144	0.94	0.59	0.07	0.14	52.84	1.27	0.00	40.41	0.10	0.41	0.38	3.40	0.06	99.16	5iA ap 9 core 1
145	0.98	0.33	0.04	0.07	52.57	1.71	0.00	40.61	0.21	0.53	0.34	2.82	0.08	99.08	5iA ap 9 core 2
146	1.97	0.15	0.07	0.02	51.08	1.34	0.00	38.94	0.58	1.88	1.31	2.81	0.07	99.01	5iA ap 9 core 3
147	1.29	0.25	0.03	0.02	52.41	1.26	0.00	40.50	0.19	0.43	0.50	3.17	0.05	98.76	5iA ap 10 core 1
148	0.07	0.10	0.02	0.00	54.69	1.71	0.00	41.51	0.05	0.03	0.06	3.28	0.00	100.14	5iA ap 10 core 2
149	1.07	0.55	0.03	0.11	52.89	1.34	0.00	40.20	0.05	0.09	0.24	3.61	0.03	98.68	5iA ap 10 core 3
150	0.50	0.26	0.03	0.01	53.51	1.42	0.00	41.18	0.09	0.07	0.27	2.84	0.03	98.99	5iA ap 11 core 1
151	0.96	0.50	0.04	0.06	52.35	1.57	0.00	40.44	0.16	0.33	0.25	2.89	0.07	98.38	5iA ap 11 core 2
152	0.78	0.19	0.02	0.01	53.35	1.54	0.00	40.28	0.18	0.29	0.24	2.76	0.04	98.49	5iA ap 11 core 3
153	0.11	0.13	0.03	0.00	53.61	1.26	0.00	39.98	0.00	0.08	0.12	3.17	0.03	97.18	5iA ap 12 side 1
154	2.08	0.57	0.02	0.07	50.10	1.37	0.00	38.51	0.51	0.88	0.71	3.04	0.12	96.66	5iA ap 12 side 2
155	0.83	0.24	0.03	0.00	52.11	1.58	0.00	39.93	0.27	0.35	0.35	3.06	0.04	97.49	5iA ap 12 side 3
156	1.20	0.68	0.01	0.08	52.88	1.36	0.00	39.78	0.00	0.25	0.35	3.50	0.05	98.64	5iA ap 13 core 1
157	0.80	0.58	0.03	0.05	53.37	1.29	0.00	40.29	0.04	0.22	0.21	3.47	0.03	98.92	5iA ap 13 core 2
158	0.62	0.23	0.02	0.00	53.75	1.23	0.00	40.13	0.13	0.20	0.21	2.92	0.02	98.20	5iA ap 14 side 1
159	0.66	0.23	0.02	0.01	52.95	1.50	0.00	40.13	0.07	0.25	0.33	2.92	0.06	97.89	5iA ap 14 side 2
160	0.67	0.25	0.02	0.02	53.29	1.45	0.00	40.25	0.11	0.25	0.24	2.83	0.03	98.21	5iA ap 14 side 3
161	0.89	0.56	0.04	0.04	52.35	1.54	0.00	40.44	0.09	0.24	0.29	2.84	0.07	98.18	5iA ap 15 side(s) 1
162	0.36	0.12	0.03	0.00	53.35	1.47	0.00	41.28	0.13	0.11	0.18	2.67	0.04	98.61	5iA ap 15 side(s) 2
163	1.20	0.90	0.03	0.08	51.28	1.54	0.00	40.29	0.16	0.45	0.41	3.11	0.07	98.17	5iA ap 16 core(c) 1
164	0.97	0.51	0.04	0.08	52.87	1.47	0.00	39.41	0.19	0.40	0.27	3.15	0.04	98.07	5iA ap 16 core(c) 2
165	0.69	0.29	0.03	0.00	53.53	1.28	0.00	39.64	0.04	0.14	0.27	3.31	0.03	97.84	5iA ap 17 c 1
166	0.70	0.37	0.05	0.00	53.89	1.27	0.00	40.49	0.07	0.10	0.32	3.15	0.03	99.10	5iA ap 17 c 2
167	0.14	0.12	0.03	0.00	54.01	1.26	0.00	39.86	0.05	0.01	0.04	3.31	0.01	97.44	5iA ap 18 s 1
168	0.81	0.57	0.04	0.07	54.39	1.34	0.00	40.72	0.00	0.16	0.21	2.97	0.04	100.05	5iA ap 18 s 2
169	0.80	0.33	0.04	0.10	53.05	1.27	0.00	41.45	0.00	0.08	0.16	3.26	0.03	99.19	5iA ap 18 s 3
170	0.61	0.41	0.04	0.04	52.49	1.32	0.00	41.12	0.00	0.16	0.14	3.19	0.03	98.18	5iA ap 19 c 1

Table Aya Apatite. (continued).

No.	SiO2	FeO	MnO	MgO	CaO	SrO	UO2	P2O5	La2O3	Ce2O3	Nd2O3	F	Cl	Total	Comment
171	0.68	0.17	0.05	0.00	53.26	1.35	0.00	41.33	0.07	0.16	0.26	3.13	0.04	99.18	5iA ap 19 c 2
172	0.61	0.19	0.01	0.00	53.47	1.32	0.00	41.20	0.02	0.07	0.17	3.03	0.03	98.82	5iA ap 19 c 3
173	0.30	0.12	0.01	0.00	54.49	1.69	0.00	41.05	0.04	0.09	0.18	3.30	0.02	99.89	5iA ap 20 c 1
174	0.12	0.09	0.01	0.00	54.33	1.58	0.00	40.88	0.00	0.01	0.05	3.22	0.01	98.93	5iA ap 20 c 2
175	0.42	0.12	0.03	0.00	53.06	1.76	0.00	40.75	0.08	0.11	0.20	3.09	0.05	98.34	5iA ap 21 core 1
176	0.11	0.07	0.02	0.00	54.16	1.46	0.00	40.92	0.00	0.04	0.05	3.22	0.01	98.70	5iA ap 21 core 2
177	0.06	0.11	0.01	0.00	54.05	1.74	0.00	42.45	0.00	0.00	0.02	2.91	0.01	100.12	5iA ap 22 core 1
178	0.04	0.12	0.02	0.00	53.97	2.20	0.00	42.65	0.00	0.06	0.03	2.81	0.01	100.72	5iA ap 22 core 2
179	0.85	0.46	0.03	0.17	53.12	1.36	0.00	40.81	0.09	0.21	0.22	2.81	0.03	98.95	5iA ap 23 core 1
180	0.66	0.38	0.04	0.02	53.34	1.36	0.00	41.27	0.04	0.18	0.27	2.89	0.06	99.27	5iA ap 23 core 2

Table Aya Apatite. Structural formula based on 25 oxygens.

No.	Si	Fe	Mn	Mg	Ca	Na	S	P	La	Ce	Pr	Nd	F	Cl	Total	Comment
3	0.093	0.086	0.007	0.015	9.473	0.022	0.085	5.564	0.010	0.014	0.003	0.013	1.610	0.021	17.014	5j circle 1 apatite 1
4	0.129	0.097	0.004	0.008	9.166	0.020	0.053	5.683	0.013	0.022	0.005	0.019	1.524	0.027	16.771	5j circle 1 apatite 2
5	0.000	0.038	0.002	0.005	9.531	0.000	0.000	5.766	0.007	0.000	0.000	0.000	1.612	0.005	16.966	5j circle 1 apatite 3
6	0.157	0.075	0.003	0.022	9.352	0.022	0.087	5.546	0.018	0.032	0.003	0.013	1.510	0.023	16.861	5j circle 1 apatite 4
8	0.165	0.120	0.007	0.027	9.275	0.026	0.109	5.536	0.007	0.015	0.002	0.017	1.406	0.020	16.731	5j circle 1 apatite 6
9	0.033	0.056	0.007	0.005	9.399	0.000	0.012	5.739	0.013	0.021	0.004	0.016	1.466	0.011	16.783	5j circle 1 apatite 7
10	0.000	0.035	0.004	0.006	9.398	0.001	0.008	5.809	0.005	0.000	0.000	0.002	1.294	0.007	16.568	5j circle 2 apatite 1
11	0.000	0.033	0.003	0.002	9.434	0.000	0.000	5.807	0.002	0.000	0.001	0.004	1.299	0.008	16.593	5j circle 2 apatite 2
12	0.000	0.024	0.000	0.000	9.469	0.002	0.004	5.797	0.001	0.000	0.000	0.000	1.494	0.007	16.798	5j circle 2 apatite 3
13	0.000	0.034	0.001	0.007	9.607	0.007	0.037	5.687	0.004	0.000	0.001	0.007	1.472	0.014	16.878	5j circle 2 apatite 4
14	0.000	0.026	0.002	0.005	9.452	0.002	0.000	5.805	0.002	0.000	0.000	0.000	1.484	0.014	16.792	5j circle 2 apatite 5
15	0.106	0.059	0.002	0.035	9.358	0.029	0.095	5.594	0.008	0.016	0.000	0.009	1.638	0.018	16.967	5j circle 3 apatite 1
16	0.201	0.087	0.002	0.051	9.279	0.035	0.105	5.504	0.015	0.023	0.004	0.016	1.651	0.014	16.986	5j circle 3 apatite 2
17	0.077	0.064	0.003	0.008	9.305	0.021	0.088	5.658	0.011	0.013	0.002	0.008	1.388	0.021	16.664	5j circle 3 apatite 3
18	0.089	0.115	0.005	0.029	9.278	0.013	0.123	5.591	0.006	0.012	0.000	0.011	1.428	0.014	16.714	5j circle 3 apatite 4
19	0.075	0.073	0.004	0.016	9.490	0.009	0.078	5.595	0.008	0.006	0.002	0.012	1.404	0.011	16.782	5j circle 3 apatite 5
20	0.113	0.077	0.003	0.025	9.366	0.036	0.091	5.574	0.016	0.020	0.000	0.017	1.589	0.015	16.940	5j circle 4 apatite 1
21	0.108	0.082	0.006	0.017	9.419	0.024	0.102	5.565	0.004	0.005	0.000	0.010	1.418	0.014	16.775	5j circle 4 apatite 2
22	0.142	0.099	0.003	0.037	9.204	0.030	0.127	5.564	0.011	0.017	0.006	0.012	1.441	0.009	16.701	5j circle 4 apatite 3
23	0.163	0.051	0.005	0.054	9.301	0.047	0.095	5.546	0.013	0.033	0.001	0.014	1.621	0.030	16.972	5j circle 4 apatite 4
24	0.085	0.054	0.000	0.026	9.448	0.033	0.074	5.607	0.004	0.013	0.004	0.009	1.551	0.016	16.925	5j circle 4 apatite 5
25	0.000	0.026	0.000	0.010	9.582	0.016	0.037	5.692	0.002	0.015	0.000	0.005	1.647	0.009	17.041	5ia circle 1 apatite 1
26	0.094	0.059	0.000	0.019	9.407	0.048	0.096	5.563	0.017	0.036	0.003	0.017	1.714	0.020	17.092	5ia circle 1 apatite 2
27	0.000	0.031	0.003	0.008	9.584	0.012	0.012	5.720	0.006	0.009	0.001	0.008	1.625	0.007	17.024	5ia circle 1 apatite 3
28	0.046	0.036	0.001	0.009	9.499	0.037	0.076	5.612	0.010	0.026	0.002	0.019	1.476	0.015	16.865	5ia circle 2 apatite 1
29	0.093	0.029	0.000	0.006	9.285	0.020	0.049	5.717	0.006	0.011	0.002	0.009	1.394	0.009	16.632	5ia circle 2 apatite 2
30	0.000	0.011	0.000	0.005	9.469	0.001	0.005	5.794	0.002	0.006	0.000	0.001	1.487	0.009	16.790	5ia circle 2 apatite 3
31	0.059	0.037	0.001	0.022	9.224	0.048	0.080	5.694	0.016	0.026	0.003	0.021	1.472	0.020	16.722	5ia circle 3 apatite 1
32	0.115	0.086	0.002	0.050	9.127	0.055	0.115	5.604	0.020	0.039	0.002	0.022	1.730	0.025	16.991	5ia circle 3 apatite 2
33	0.000	0.023	0.003	0.005	9.514	0.018	0.045	5.709	0.006	0.012	0.001	0.007	1.446	0.014	16.803	5ia circle 3 apatite 3
34	0.000	0.021	0.002	0.006	9.613	0.002	0.006	5.731	0.000	0.009	0.000	0.000	1.644	0.013	17.046	5ia circle 4 apatite 1
35	0.000	0.015	0.000	0.005	9.466	0.013	0.007	5.789	0.000	0.008	0.002	0.000	1.613	0.010	16.927	5ia circle 4 apatite 2
36	0.118	0.059	0.003	0.020	9.306	0.048	0.098	5.576	0.013	0.041	0.004	0.022	1.605	0.020	16.932	5ia circle 4 apatite 3
37	0.000	0.013	0.000	0.007	9.447	0.009	0.011	5.784	0.004	0.014	0.004	0.002	1.411	0.011	16.717	5ia circle 5 apatite 1
38	0.000	0.027	0.000	0.009	9.469	0.018	0.047	5.723	0.004	0.011	0.003	0.007	1.334	0.007	16.659	5ia circle 5 apatite 2
39	0.000	0.018	0.000	0.009	9.427	0.005	0.000	5.811	0.004	0.008	0.000	0.000	1.585	0.011	16.876	5ia circle 5 apatite 3

Table Aya Apatite. (continued).

No.	Si	Fe	Mn	Mg	Ca	Sr	U	P	La	Ce	Nd	F	Cl	Total	Comment	
40	0.012	0.022	0.004	0.007	9.440	0.040	0.053	5.709	0.002	0.012	0.004	0.019	1.501	0.010	16.833	5ia circle 6 apatite 1
41	0.000	0.020	0.001	0.006	9.499	0.036	0.034	5.715	0.006	0.023	0.003	0.014	1.464	0.013	16.832	5ia circle 6 apatite 2
42	0.017	0.017	0.003	0.006	9.490	0.036	0.055	5.670	0.011	0.029	0.006	0.014	1.588	0.013	16.956	5ia circle 6 apatite 3
43	0.000	0.036	0.003	0.000	9.644	0.011	0.028	5.684	0.001	0.004	0.002	0.005	1.580	0.007	17.005	5ib circle 1 apatite 1
44	0.146	0.153	0.002	0.026	9.275	0.046	0.174	5.438	0.017	0.036	0.009	0.013	1.380	0.025	16.741	5ib circle 1 apatite 2
45	0.100	0.090	0.002	0.000	9.327	0.038	0.108	5.580	0.014	0.027	0.001	0.018	1.408	0.022	16.735	5ib circle 1 apatite 3
46	0.148	0.081	0.002	0.056	9.358	0.042	0.098	5.525	0.012	0.021	0.004	0.018	1.336	0.014	16.713	5ib circle 1 apatite 4
47	0.093	0.061	0.006	0.012	9.446	0.040	0.098	5.555	0.015	0.027	0.004	0.012	1.527	0.029	16.925	5ib circle 1 apatite 5
48	0.085	0.070	0.004	0.002	9.543	0.039	0.088	5.537	0.011	0.022	0.006	0.019	1.518	0.013	16.956	5ib circle 2 apatite 1
49	0.000	0.040	0.003	0.000	9.586	0.003	0.004	5.741	0.003	0.000	0.000	0.001	1.579	0.005	16.964	5ib circle 2 apatite 2
50	0.000	0.042	0.003	0.000	9.631	0.000	0.009	5.714	0.003	0.001	0.000	0.003	1.359	0.007	16.773	5ib circle 2 apatite 4
51	0.000	6.514	0.155	0.000	0.131	0.000	0.894	0.000	2.704	5.637	0.345	0.993	0.000	0.000	17.373	5ib circle 2 apatite 5
52	0.024	0.055	0.001	0.000	9.535	0.019	0.071	5.639	0.004	0.009	0.003	0.010	1.473	0.007	16.851	5ib circle 3 apatite 1
53	0.111	0.051	0.005	0.006	9.408	0.048	0.095	5.559	0.016	0.033	0.002	0.015	1.709	0.022	17.081	5ib circle 3 apatite 2
54	0.000	0.024	0.001	0.000	9.664	0.010	0.029	5.680	0.005	0.005	0.000	0.004	1.405	0.006	16.832	5ib circle 3 apatite 3
55	0.039	0.050	0.003	0.000	9.582	0.028	0.071	5.605	0.002	0.012	0.000	0.018	1.590	0.016	17.016	5ib circle 3 apatite 4
56	0.000	0.037	0.004	0.000	9.649	0.004	0.028	5.684	0.001	0.002	0.000	0.007	1.297	0.008	16.721	5ib circle 3 apatite 5
57	0.056	0.050	0.001	0.000	9.612	0.026	0.075	5.573	0.008	0.013	0.002	0.015	1.632	0.005	17.066	5ib circle 4 apatite 1
58	0.000	0.023	0.003	0.000	9.717	0.001	0.006	5.694	0.000	0.002	0.000	0.001	1.611	0.003	17.060	5ib circle 4 apatite 2
59	0.000	0.013	0.002	0.000	9.563	0.003	0.005	5.759	0.001	0.001	0.000	0.003	1.411	0.006	16.768	5ib circle 4 apatite 3
60	0.000	0.032	0.004	0.010	9.728	0.003	0.016	5.663	0.007	0.000	0.000	0.004	1.697	0.001	17.166	5ib circle 4 apatite 4
61	0.000	0.019	0.002	0.000	9.597	0.001	0.002	5.746	0.001	0.000	0.001	0.004	1.564	0.004	16.940	5ib circle 4 apatite 5

Table Aya Apatite. (continued).

No.	Si	Fe	Mn	Mg	Ca	Sr	U	P	La	Ce	Nd	F	Cl	Total	Comment
135	0.159	0.056	0.008	0.027	9.808	0.185	0.000	5.803	0.011	0.028	0.022	1.574	0.028	17.708	5iA ap 1
136	0.104	0.027	0.008	0.009	9.837	0.138	0.000	5.880	0.010	0.020	0.019	1.728	0.008	17.788	5iA ap 2
137	0.127	0.071	0.007	0.004	9.679	0.131	0.000	5.911	0.004	0.028	0.019	1.635	0.019	17.634	5iA ap 3
138	0.160	0.031	0.010	0.007	9.745	0.154	0.000	5.843	0.012	0.042	0.030	1.617	0.012	17.663	5iA ap 4
139	0.194	0.049	0.004	0.035	9.619	0.151	0.000	5.856	0.013	0.042	0.021	1.480	0.029	17.492	5iA ap 5
140	0.129	0.043	0.005	0.010	9.680	0.133	0.000	5.916	0.002	0.031	0.022	1.614	0.014	17.598	5iA ap 6 side 1
141	0.156	0.064	0.008	0.023	9.629	0.154	0.000	5.885	0.010	0.034	0.021	1.639	0.018	17.641	5iA ap 6 side 2
142	0.188	0.115	0.006	0.040	9.907	0.128	0.000	5.744	0.004	0.020	0.021	1.897	0.021	18.091	5iA ap 7
143	0.077	0.028	0.009	0.002	9.861	0.128	0.000	5.915	0.000	0.014	0.007	1.775	0.010	17.826	5iA ap 8
144	0.161	0.085	0.010	0.035	9.694	0.126	0.000	5.858	0.006	0.026	0.023	1.843	0.016	17.883	5iA ap 9 core 1
146	0.342	0.022	0.011	0.006	9.492	0.135	0.000	5.718	0.037	0.119	0.081	1.542	0.019	17.523	5iA ap 9 core 3
147	0.221	0.036	0.005	0.005	9.610	0.125	0.000	5.869	0.012	0.027	0.031	1.716	0.014	17.670	5iA ap 10 core 1
148	0.011	0.015	0.003	0.000	9.914	0.168	0.000	5.946	0.003	0.002	0.004	1.754	0.000	17.819	5iA ap 10 core 2
149	0.184	0.079	0.005	0.027	9.736	0.133	0.000	5.847	0.003	0.006	0.015	1.962	0.008	18.005	5iA ap 10 core 3
150	0.086	0.037	0.005	0.003	9.764	0.140	0.000	5.937	0.006	0.004	0.016	1.529	0.008	17.533	5iA ap 11 core 1
151	0.165	0.072	0.006	0.016	9.640	0.156	0.000	5.885	0.010	0.021	0.016	1.571	0.020	17.577	5iA ap 11 core 2
152	0.134	0.027	0.002	0.002	9.825	0.153	0.000	5.863	0.011	0.018	0.015	1.500	0.013	17.563	5iA ap 11 core 3
153	0.020	0.019	0.005	0.000	10.024	0.127	0.000	5.907	0.000	0.005	0.007	1.752	0.008	17.873	5iA ap 12 side 1
154	0.366	0.085	0.002	0.017	9.458	0.140	0.000	5.746	0.033	0.056	0.045	1.694	0.036	17.677	5iA ap 12 side 2
155	0.145	0.035	0.004	0.000	9.714	0.159	0.000	5.882	0.018	0.022	0.022	1.684	0.011	17.695	5iA ap 12 side 3
156	0.206	0.098	0.001	0.020	9.764	0.136	0.000	5.805	0.000	0.016	0.022	1.906	0.014	17.988	5iA ap 13 core 1
157	0.137	0.083	0.004	0.013	9.815	0.129	0.000	5.855	0.003	0.014	0.013	1.883	0.008	17.956	5iA ap 13 core 2
158	0.106	0.033	0.002	0.000	9.931	0.123	0.000	5.860	0.008	0.013	0.013	1.592	0.006	17.686	5iA ap 14 side 1
159	0.115	0.033	0.003	0.002	9.818	0.151	0.000	5.880	0.004	0.016	0.020	1.599	0.017	17.660	5iA ap 14 side 2
160	0.115	0.036	0.003	0.005	9.842	0.145	0.000	5.874	0.007	0.016	0.015	1.544	0.010	17.611	5iA ap 14 side 3
161	0.153	0.080	0.005	0.011	9.654	0.154	0.000	5.893	0.006	0.015	0.018	1.545	0.020	17.553	5iA ap 15 side(s) 1
162	0.062	0.018	0.004	0.000	9.757	0.145	0.000	5.966	0.008	0.007	0.011	1.443	0.010	17.430	5iA ap 15 side(s) 2
163	0.206	0.129	0.004	0.022	9.475	0.154	0.000	5.884	0.010	0.028	0.025	1.698	0.020	17.654	5iA ap 16 core(c) 1
164	0.169	0.074	0.006	0.020	9.841	0.148	0.000	5.797	0.012	0.026	0.017	1.728	0.012	17.849	5iA ap 16 core(c) 2
165	0.119	0.042	0.005	0.000	9.965	0.129	0.000	5.832	0.002	0.009	0.017	1.817	0.009	17.945	5iA ap 17 c 1
166	0.120	0.053	0.007	0.000	9.873	0.126	0.000	5.862	0.005	0.006	0.020	1.703	0.008	17.783	5iA ap 17 c 2
167	0.025	0.017	0.005	0.000	10.087	0.128	0.000	5.882	0.003	0.001	0.002	1.822	0.002	17.973	5iA ap 18 s 1
168	0.137	0.081	0.006	0.016	9.866	0.132	0.000	5.837	0.000	0.010	0.012	1.592	0.010	17.699	5iA ap 18 s 2
169	0.136	0.047	0.006	0.026	9.635	0.125	0.000	5.948	0.000	0.005	0.010	1.750	0.009	17.694	5iA ap 18 s 3
170	0.105	0.058	0.006	0.010	9.641	0.131	0.000	5.967	0.000	0.010	0.009	1.728	0.008	17.671	5iA ap 19 c 1
171	0.116	0.024	0.007	0.000	9.696	0.133	0.000	5.945	0.004	0.010	0.016	1.682	0.012	17.646	5iA ap 19 c 2

Table Aya Apatite. (continued).

No.	Si	Fe	Mn	Mg	Ca	Sr	U	P	La	Ce	Nd	F	Cl	Total	Comment
172	0.104	0.027	0.001	0.000	9.757	0.130	0.000	5.941	0.001	0.004	0.010	1.631	0.008	17.615	5iA ap 19 c 3
173	0.051	0.016	0.002	0.000	9.921	0.167	0.000	5.905	0.002	0.005	0.011	1.773	0.005	17.859	5iA ap 20 c 1
174	0.020	0.013	0.001	0.000	9.968	0.157	0.000	5.926	0.000	0.000	0.003	1.743	0.002	17.834	5iA ap 20 c 2
175	0.072	0.017	0.005	0.000	9.783	0.176	0.000	5.937	0.005	0.007	0.012	1.683	0.013	17.708	5iA ap 21 core 1
176	0.019	0.010	0.004	0.000	9.947	0.145	0.000	5.939	0.000	0.002	0.003	1.747	0.003	17.819	5iA ap 21 core 2
177	0.010	0.015	0.002	0.000	9.717	0.169	0.000	6.031	0.000	0.000	0.001	1.542	0.002	17.488	5iA ap 22 core 1
178	0.007	0.017	0.003	0.000	9.661	0.213	0.000	6.033	0.000	0.003	0.002	1.483	0.003	17.426	5iA ap 22 core 2
179	0.144	0.065	0.004	0.042	9.698	0.134	0.000	5.888	0.006	0.013	0.013	1.516	0.008	17.531	5iA ap 23 core 1
180	0.112	0.053	0.006	0.005	9.702	0.134	0.000	5.932	0.003	0.011	0.016	1.550	0.018	17.542	5iA ap 23 core 2

APPENDIX II
Geochemical Data

Trace Elements (Fusion-ICP/MS)

Element	Detection Limit (ppm)	Element	Detection Limit (ppm)	Element	Detection Limit (ppm)
Ag	0.5	Ni	10	La	0.01
As	5	Pb	5	Ce	0.01
Ba	0.1	Rb	0.1	Pr	0.005
Bi	0.05	Sb	0.05	Nd	0.01
Co	0.5	Sn	0.5	Sm	0.01
Cr*	10	Sr	0.01	Eu	0.005
Cs	0.1	Ta	0.01	Gd	0.01
Cu	10	Th	0.05	Tb	0.01
Ga	1	Tl	0.05	Dy	0.01
Ge	0.5	U	0.05	Ho	0.01
Hf	0.1	V	5	Er	0.01
In	0.1	W	0.2	Tm	0.005
Mo	0.1	Y	0.1	Yb	0.01
Nb	0.5	Zn	10	Lu	0.002
Zr	0.1	-	-	-	-

- All chrome values listed in text and displayed in tables have been corrected (-200 ppm) from the original value because of contamination during the crushing stage.

Errors Associated with Trace Element Data

- Values *at detection limit* have an associated error of ± 100 % of the determined value (e.g., 0.01 ppm La ± 0.01 ppm).
- Values *10 times detection limit* have an associated error of ± 10-15 % of the determined value (e.g., 0.1 ppm La ± 0.01-0.015 ppm).
- Values *100 times detection limit* have an associated error of ± < 5 % of the determined value (e.g., 1.0 ppm La ± < 0.05 ppm).

Major Elements to 0.01% (XRF)

SiO_2	Fe_2O_3	MgO	TiO_2
Al_2O_3	MnO	Na_2O	LOI
CaO	P_2O_5	K_2O	

Other Analyses

	REPORTING LIMIT (%)	METHOD
CO_2	0.01	Leco
H_2O^+, H_2O^-	0.1	Gravimetric

Major Element Data for Meliadine Kimberlite Dykes and Aya Ultramafic.

wt. %	Peter II	K-L 2A-5	K-L 2A-7	K-L 2B-6	Aya1	Aya2
SiO_2	15.09	16.83	17.69	21.80	37.96	39.27
TiO_2	1.33	1.31	1.52	0.95	1.26	1.27
Al_2O_3	1.44	1.64	1.81	1.14	7.91	7.94
Fe_2O_3	6.95	9.21	11.27	9.27	8.77	8.51
MnO	0.25	0.32	0.29	0.21	0.13	0.11
MgO	14.99	15.19	14.31	17.16	16.15	8.32
CaO	25.03	22.34	21.21	18.65	10.18	14.52
Na_2O	0.68	0.73	0.66	0.88	0.29	0.64
K_2O	0.78	0.24	0.17	0.18	4.24	4.47
P_2O_5	0.76	1.07	1.33	0.96	0.81	2.65
H_2O^+	0.88	0.91	0.95	1.17	0.34	0.45
H_2O^-	1.95	2.56	3.35	3.98	0.75	0.23
CO_2	17.35	13.76	16.25	16.03	8.13	10.56
LOI	31.59	29.15	27.85	27.13	9.90	10.35
Total	98.88	98.04	98.12	98.33	97.59	98.03

Trace Element Data for Meliadine Kimberlite Dykes and Aya Ultramafic.

Element (ppm)	Peter II	K-L 2A-5	K-L 2A-7	K-L 2B-6	Aya1	Aya2
V	181	143	162	119	152	189
Cr**	557	645	678	624	1651	163
Co	70.1	67.6	66.8	67.1	58.6	44.6
Ni	661	631	586	787	602	73
Cu	86	53	69	51	9	81
Zn	60	54	66	51	71	63
Ga	9	9	11	6	13	16
Ge	1.1	1.3	2.3	1.6	2	2
As	9	16	11	8	196	61
Rb	47.93	21.92	12.48	23.44	164.37	147.37
Sr	1194.97	1447.06	1482.13	1242.66	385.74	847.64
Y	52.1	97	46.7	20	128.5	194.6
Zr	197.49	196.23	317.5	198.92	242.78	314.1
Nb	251.98	218.33	251	204.64	14.79	16.66
Mo	0.38	1.11	0.3	0.26	0.54	2.5
Ag	dt	dt	dt	dt	dt	dt
In	dt	dt	dt	dt	dt	dt
Sn	0.8	0.5	0.9	0.3	1.7	1.7
Sb	0.24	0.32	0.27	0.32	0.29	0.27
Cs	1.22	0.84	0.69	3.52	11.58	11.82
Ba	859.03	1218.37	821.06	1187.97	3467.29	3356.24
La	150.83	168.76	167.27	115.71	129.34	225.31
Ce	252.79	292.61	306.93	194.35	249	439.16
Pr	21.603	25.912	27.199	16.552	23.168	41.611
Nd	77.62	96.13	97.71	58.73	89.29	161.16
Sm	12.79	15.11	15.52	9.32	16.02	29.09
Eu	3.374	4.057	4.061	2.586	3.997	6.888
Gd	10.37	13.16	12.32	7.37	13.24	22.55
Tb	1.27	1.54	1.23	0.79	2.07	3.34
Dy	6.86	8.2	5.46	3.51	15.9	24.44
Ho	1.68	1.93	1.04	0.69	4.13	6.16
Er	8.74	6.59	3.41	2.55	16.6	24.04
Tm	1.832	0.813	0.356	0.385	2.794	4.021

Element (ppm)	Peter II	K-L 2A-5	K-L 2A-7	K-L 2B-6	Aya1	Aya2
Yb	14.26	4.35	1.78	2.69	19.15	26.99
Lu	2.389	0.631	0.284	0.417	2.987	4.166
Hf	5.31	5.79	7.14	4.51	7.06	8.62
Ta	8.532	9.551	10.51	6.368	0.487	0.468
W	7.36	1.99	1.33	2.33	7.47	5.38
Tl	0.15	0.1	0.05	0.28	1.64	1.34
Pb	13	12	11	10	33	33
Bi	dt	dt	dt	dt	0.31	0.39
Th	257.778	40.275	26.304	60.56	376.765	885.381
U	16.312	5.756	4.906	5.191	4.509	6.047

dt= at detection limit; **= uncorrected values.

APPENDIX III

Analytical Procedures (Sr-Nd and U-Pb)

Sr-Nd Procedure

Isotopic work was conducted at the University of Alberta in the Earth and Atmospheric Sciences Radiogenic Isotope Facility. Rb-Sr and Sm-Nd work were completed on six whole-rocks and two phlogopite mineral separates using cation exchange chromatography and isotope dilution techniques (R.A. Creaser, pers. comm., 1997). Phlogopite samples were initially leached in dilute (0.75N HCl) and placed in an ultrasonic bath for 15min, then heated at 100 °C for 15min. This initial step was completed in order to remove any trace amounts of carbonate that could possibly effect the Rb-Sr age. Whole-rock powdered samples for Sr and Nd were weighed and spiked with tracer solutions of ^{84}Sr and ^{87}Rb, and ^{150}Nd and ^{149}Sm, respectively. Phlogopite samples were only spiked with ^{84}Sr and ^{87}Rb. All samples were then dissolved in a 5:2 mix of vapour distilled 24N HF and 16N HNO_3 in sealed PFA teflon vials at 150 °C for 168 hours (Nd samples) and 24 hours (Sr samples), respectively. The HF mixtures were then evaporated to yield dried fluoride residues. Residues were converted to chloride solutes by the addition of 6N HCl and heated to 150 °C for 24 hours. The HCl mixtures were then evaporated to dryness, 0.75N HCl was added to the whole-rock chloride residues, and an Oxalic-HCl acid mix added to the phlogopite samples. All samples were then heated at 100 °C for 12 hours. The rare earth elements (REE), Rb, Sr, and Nd were separated from the dried chloride residues using AG50-X8 200-400 mesh cation exchange resin for separation by chromatography in PFA Teflon columns. Nd and Sm were separated from the REE and one another using Di (2-ethylhexyl phosphate) chromatography (HDEHP). The separated Sr, Nd, and Rb, Sm, were then loaded on Re-filaments and analyzed on a VG-354 mass spectrometer and a MM30 mass spectrometer, respectively. All mass spectrometer work was completed by Dr. R.A. Creaser, and O. Levner. Raw ratios for Nd and Sm were corrected for variable mass discrimination to ^{146}Nd/^{144}Nd= 0.7219 and ^{152}Sm/^{154}Sm= 1.17537 using the exponential law (Wasserburg et al., 1981), and for the effects of low abundance (non-^{150}Nd) and (non-^{149}Sm) tracer Nd and Sm isotopes, respectively. A spiked aliquot of the La Jolla Nd isotopic standard yielded a ^{143}Nd/^{144}Nd of 0.511848 ± 0.000008. External reproducibility of ± 0.000016 (2σ) was obtained on multiple analyses from an unspiked in-house standard (cf. Creaser et al., 1997). Raw ratios for Sr were corrected for variable mass discrimination to ^{86}Sr/^{87}Sr= 0.1194 using the exponential law, and for the effects of low abundance (non-^{84}Sr) tracer Sr isotopes. Multiple runs on SRM 987 gave spike-unmixed ^{87}Sr/^{86}Sr= 0.710232 ± 0.000012 (2σ) with a minimum estimation of external reproducibility for ^{87}Sr/^{86}Sr of ± 0.00002 (2σ), on repeated analyses of the SRM 987 standard.

U-Pb Geochronology Procedure (cf. Heaman, 1989)

High purity perovskite concentrates were obtained from the K-L 2B kimberlite dyke, and apatite from the K-L 2a and K-L 2B dykes by conventional crushing (Bico disk mill) and heavy liquid techniques (TBE heavy liquids). Grains selected for the study were individually picked under a binocular microscope at high magnification with selection based on habit (subhedral-to-euhedral), lack of inclusions, alteration, and miscellaneous coatings. All perovskite samples (~ 400) were 25-50 μm dark brown/purple cubes, while apatite (~ 200) were roughly 45 x 20 μm hexagonal columnar grains.

Procedures for the isolation of U and Pb using the HBr technique with a VG-354 mass spectrometer in single collector mode to measure the isotopic compositions is essentially unchanged from the techniques as described by Heaman (1989). Analytical procedural blanks for the study were 8 pg Pb and 2 pg U, with all isotopic data corrected for mass discrimination (+0.09 %/amu Pb and +0.16 %/amu U), tracer contribution and blank (Heaman, pers. comm., 1998). Furthermore, the two-stage average crustal Pb model of Stacey and Kramer (1975) was used to correct ^{206}Pb/^{238}U for the presence of initial common Pb. Decay constants from Jaffey et al. (1971) for ^{238}U (1.55125×10^{-10} yr.$^{-1}$) and ^{235}U (9.8485×10^{-10} yr.$^{-1}$) were used in the age calculations.